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ADAPTATION OF CREW PERFORMANCE, STRESS AND MOOD

ABOARD A SWATH AND MONOHULL VESSEL

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16. Abstract

In the Spring of 1978 a study was conducted to measure the effects of vessel motions characteristic to a 89' Navy Small Waterplane Area Twin Hull (SWATH) vessel, a 95' Coast Guard Patrol Boat and a 378' Coast Guard High Endurance Cutter upon various psychomotor and cognitive performance tasks and physiological and psychological indexes of stress. These measures were repeatedly sampled from eighteen Coast Guardsmen who were exposed to each vessel at sea for an eight hour period. During the eight hours the vessels steamed two octogonal patterns through sea state three seas in a side-by-side manner. Motions experienced aboard the patrol boat led to severe motion sickness, stress, deterioration in mood and decrements in the majority of performance tests administered. The SWATH vessel's subdued motion environment, equivalent to that of the much large High Endurance Cutter, did not produce such outcomes. These finding, however, were bounded by the briefness of exposures, the lack of measurable adaptation to the everchanging motion environments brought about by frequent course changes, and the inability to separate the contributions of motion sickness and vessel dynamics toward performance decrement and stress responses.

If subject stress and performance task decrements were a result of motion sickness alone, then the advantages of the SWATH vessel over comparably sized monohulls would only be periodic and transitory in nature. The purpose of this study was to expose subjects, during the last two days of vessel availability, to a sustained motion environment aboard the SWATH vessel and patrol boat in an effort to determine the rate and magnitude of subject adaptation to each vessel's dynamics. Moreover, it was hoped that declines in motion sickness severity and sustained vessel motions would indicate the magnitude of their roles in performance decrement, stress and mood deterioration.

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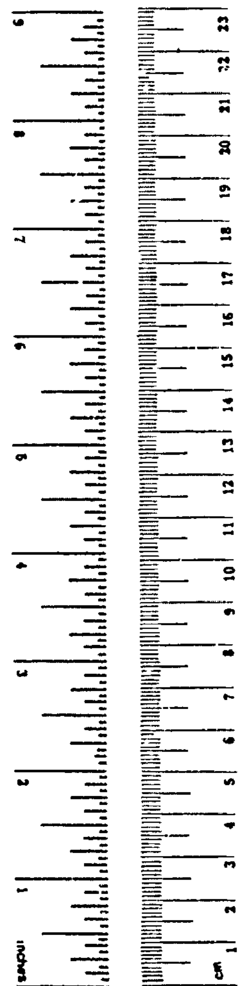
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

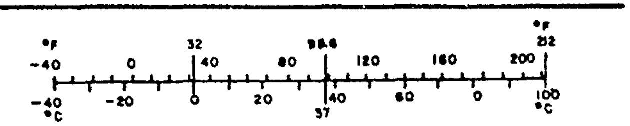
Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in ≡ 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



ADAPTATION OF CREW PERFORMANCE, STRESS AND MOOD

ABOARD A SWATH AND MONOHULL VESSEL

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SUMMARY

The objectives of this study were to examine the effects of actual vessel motions, characteristic to a 89' Navy Small Waterplane Area Twin Hull (SWATH) vessel and a 95' Guard Patrol Boat, upon motion sickness incidence and severity, objective physiol indexes of motion sickness and stress, indexes of mood, and levels of crew psychomotor and cognitive performance prior to and subsequent to adaptation.

Psychomotor performance (navigation plotting, critical tracking, code substitution, complex counting, time estimation and Spoke Test), motion sickness urine output and specific gravity, stress hormone excretion (catecholamines and 17-hydroxycorticosteroids), heart and sweat rates, and subject mood were repeatedly sampled from 11 young male Coast Guardsmen during a three day period. Data collected during eight hours spent dockside were compared to the first and last eight hours of a thirty-two hour continuous exposure to vessel motions at sea. Each vessel was instrumented with accelerometers to continuously record vertical, lateral and longitudinal accelerations within the respective test compartments located below decks amidships.

Results showed that as the vessels steamed through calm seas in the mornings, and into less than sea state three conditions in the afternoon each day, subjects aboard the WPB experienced motion sickness, antidiuresis, and decrements in code substitution, navigation plotting and Spoke test performance. Subjects aboard the SWATH vessel did not experience motion sickness, changes in other physiological variables measured, or in the majority of performance tasks administered (small decrements were found in the navigation plotting and Spoke Test(control) metrics aboard the SWATH) at sea. The reponses noted in subjects aboard the patrol boat were significantly correlated to motion sickness severity and vessel motions (vertical and lateral rms g accelerations) associated with motion sickness. The small shifts observed in subject mood with the introduction of vessel motion and motion sickness appeared to be unrelated to motion sickness or vessel motion severity.

During the second day at sea subjects exhibited signs of physiological adaptation to the motion environment aboard the patrol boat. Moderate reductions in physiological responses were associated with small improvements in performance tasks degraded during the first day at sea. No significant changes in subject mood were found with physiological adaptation. The results show that reliance upon crew adaptation to motion environments would be a far less effective measure in motion sickness prevention or reduction than that of improved vessel ride quality characteristics.

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LIST OF ABBREVIATIONS

ADH	Antidiuretic Hormone
CTT	Critical Tracking Task
GGAS	General Gravity Adaptation Syndrome
17-OHCS	17-Hydroxycorticosteriods
MACL	Mood Adjective Checklist
MSI	Motion Sickness Incidence
MSSS	Motion Sickness Symptomatology Severity
rms	Root Mean Square
SS	Sea State
SSP	89' Navy Semi-Submersible Platform
SWATH	Small Water Area Twin Hull
WHEC	378' Coast Guard High Endurance Cutter
WPB	95' Coast Guard Patrol Boat
λ_c	Critical Tracking Task Bandwidth Limit
g	Gravity
n	Number of subjects
$\bar{\Delta}$	Mean change

INTRODUCTION

In the Spring of 1978 a study was conducted to measure the effects of vessel motions characteristic to a 89' Navy Small Waterplane Area Twin Hull (SWATH) vessel, a 95' Coast Guard Patrol Boat and a 378' Coast Guard High Endurance Cutter upon various psychomotor and cognitive performance tasks and physiological and psychological indexes of stress. These measures were repeatedly sampled from eighteen Coast Guardsmen who were exposed to each vessel at sea for an eight hour period. During the eight hours the vessels steamed two octogonal patterns through sea state three seas in a side-by-side manner. Motions experienced aboard the patrol boat led to severe motion sickness, stress, deterioration in mood and decrements in the majority of performance tests administered. The SWATH vessel's subdued motion environment, equivalent to that of the much larger High Endurance Cutter, did not produce such outcomes. These findings, however, were bounded by the briefness of exposures, the lack of measurable adaptation to the ever-changing motion environments brought about by frequent course changes, and the inability to seperate the contributions of motion sickness and vessel dynamics toward performance decrement and stress responses.

If subject stress and performance task decrements were a result of motion sickness alone, then the advantages of the SWATH vessel over comparably sized monohulls would only be periodic and transitory in nature. The purpose of this study was to expose subjects, during the last two days of vessel availability, to a sustained motion environment aboard the SWATH vessel and patrol boat in an effort to determine the rate and magnitude of subject adaptation to each vessel's dynamics. Moreover, it was hoped that declines in motion sickness severity and sustained vessel motions would indicate the magnitude of their roles in performance decrement, stress and mood deterioration.

BACKGROUND

In the Spring of 1978 a study was conducted to examine the effects of actual vessel motions, characteristic to a 89' Navy Small Waterplane Area Twin Hull (SWATH) vessel, a 95' Coast Guard Patrol Boat and a 378' Coast Guard High Endurance Cutter, upon motion sickness incidence and severity, objective physiological indexes of stress, subjective reports of mood and various psychomotor and cognitive performance tasks (Wiker, Pepper and McCauley, 1980). The experiment was conducted primarily to determine if the SWATH vessel design, represented by the 89' Navy Semi-Submersible Platform, would offer measurable advantages over comparably sized and larger monohull vessels in the areas of crew habitability and performance.

Psychomotor and cognitive task performance (code substitution, complex counting, navigational plotting, Spoke Test and time estimation), motion sickness symptomatology, urine output and specific gravity, urinary excretion of 17-hydroxy-corticosteroids (17-OHCS) and catecholamines, heart and sweat rates, and subject mood were repeatedly sampled from 18 male Coast Guardsmen during a six consecutive day period. Each subject spent two eight-hour days aboard each vessel; one day at dockside and another at sea. For detailed discussions of the measures noted above and the measurement techniques involved see Wiker et al., 1980.

During the periods spent at sea, the vessels steamed together at 7 to 10 knots in four-hour octogonal patterns about a wave measurement bouy. All vessels were instrumented with accelerometers to continuously record vertical, lateral and longitudinal accelerations within test compartments housing test subjects below decks amidships. Roll, pitch and heave motions were also recorded at nearby vessel centers of gravity.

Results from the study showed that as the vessels steamed through sea state 3 seas, no motion sickness, significant stress, mood deterioration or performance decrements were experienced aboard the comparably stable high endurance cutter and smaller SWATH vessel. However, the considerably more dynamic environment found aboard the patrol boat led to severe motion sickness, reduction in urine output, elevations in urine specific gravity and urinary excretion of 17-OHCS, slight deterioration in mood, and small to moderate decrements in all performance tasks measured.

In general, physiological and psychological indexes of stress, as well as declines in task performance were significantly correlated with elevations in motion sickness severity and vessel motions correlated with motion sickness incidence. Vessel motions, or vessel motion characteristics, unrelated to motion sickness were not associated with the aforementioned subject responses.

Vessel motion records indicated that vessel vertical acceleration characteristics, not rolling or pitching motions, were predominantly responsible for motion sickness onset and severity aboard the patrol boat. Motion sickness became increasingly severe as the vertical motion frequencies declined to a limit of 0.20 Hz. Increasing the amplitudes of vertical motions at any given frequency led to additive increases in motion sickness severity.

Based upon the results of this previous study, it is clear that increased vessel stability afforded by the SWATH design prevented motion sickness, stress, and permitted measurably better performance than did a comparably sized monohull in sea state 3 conditions. However, the findings of the study were restricted; it was not possible to estimate the relative contributions of motion sickness and postural challanges in decrements observed in psychomotor performance or the rate of adaptation of the subjects to their motion environments.

Factors such as age, possibly sex, subject arousal level and previous exposure history to unusual force environments can effect an individual's susceptibility to motion sickness Money, 1970; Collins, 1974). Adaptation and eventual habituation to force environments regularly experienced aboard a crewmen's vessel is generally anticipated. The phenomenon is widely reported in the scientific literature and is believed to be an adaptive response to changes in acceleration stimuli associated with growth and aging processes (Brown, 1965;

Reason and Craybiel, 1970; Collins, 1974; Guedry, 1974; Watts, 1979).

Although the exact mechanism is unknown, it appears that the process of vestibular adaptation is centrally controlled. Symmetrical stimulation to the endorgans does not produce adaptation or habituation (Collins, 1965) while repeated unilateral caloric stimulation of the vestibular apparatus produces habituation in both ears (Capps and Collins, 1965). Furthermore, central nervous system depressants will release habituation (Collins, 1974) as will general alarm reactions (Crampton and Schwam, 1961).

Characteristically, habituation occurs most rapidly and is sustained for longest periods when the stimuli are presented in a distrubuted manner (Brown, 1965); thus, suggesting habiutation is a learned phenomemon (Watts, 1979). The habituation response is also very specific to the stimuli presented as demonstrated in figure skaters, dancers, pilots, railroadmen and sailors who exhibit response declines to only acceleration stimuli similar to those experienced in their occupational or avocational pursuits (Collins, 1966; Osterhammel et al., 1968; Reason and Brand, 1975).

If motion sickness were primarily responsible for the observed physiological, psychological and task performance changes reported in the previous study, then a sustained exposure to the vessel motion environment aboard the patrol boat should produce an adaptive response in subjects leading to a reduction in motion sickness severity and associated phenomena. Subject responses tied directly to mechanical interference should not vary significantly as motion sickness declines in severity.

METHODS AND APPARATUS

Subjects

Eleven* Coast Guardsmen were randomly selected from a population of eighteen subjects who had participated in an earlier study. The procedures used in the initial selection of the larger subject population are provided by Wiker et al., 1980.

All subjects were males who claimed to be in good health. Subjects reported a history of average susceptibility to motion sickness and a normal concern for performance aboard ship, on school exams and in sporting activities. No subjects smoked or had a habit of drinking alcohol heavily. Summary statistics of physical and shipboard sexperience characteristics of the subject population are provided in Table 1.

Subject participation was voluntary and on an informed consent basis (see Appendix B). No rewards were provided to the subjects. However, regular duty was suspended during the period of testing and a ninty-six hour liberty authorization was provided to compensate for curtailed liberty during the period of experimentation.

Apparatus

Data collection was conducted within similar ship's compartments located amidships and below deck aboard a 95' WPB Coast Guard Patrol Boat and an 89' SSP Navy Semi-Submersible Platform (SWATH) vessel. The test vessels are shown in Figure 1

*Twelve subjects were originally selected, however, one subject did not report for the experiment.

TABLE 1

SUBJECT PHYSICAL AND SHIPBOARD EXPERIENCE CHARACTERISTICS

	Age (yrs)	Height (cm)	Weight (kg)	Recent Shipboard Experience (mons)
95' WPB				
$\bar{x} \pm$ SD	19.6 $\pm$ 1.5	179.3 $\pm$ 8.2	69.5 $\pm$ 5.6	9.4 $\pm$ 5.3
Range	17 - 22	170.2 - 188	62 - 78	0.5 - 18
89' SSP				
$\bar{x} \pm$ SD	21.0 $\pm$ 1.8	180.3 $\pm$ 5.8	77.4 $\pm$ 5.8	11.3 $\pm$ 4.2
Range	18 - 24	172.4 - 190	66 - 84	4.0 - 18

Each vesse was instrumented to record test compartment translational and vessel center of gravity motions. Vessel centers of gravity were located within five to ten feet from a given test compartment. Detailed specifications of accelerometer placement, calibration, signal conditioning, digitilization of taped analog motion responses, analysis procedures and vessel motion results are provided elsewhere (Woolaver and Peters, 1980).

Each vessel was instrumented to record test compartment temperatures and relative humidities using a Mason's form hygrometer. Sound decibel level records were made in the test compartments while the vessels were underway using a General Radio Company Octave-Band Analyzer.

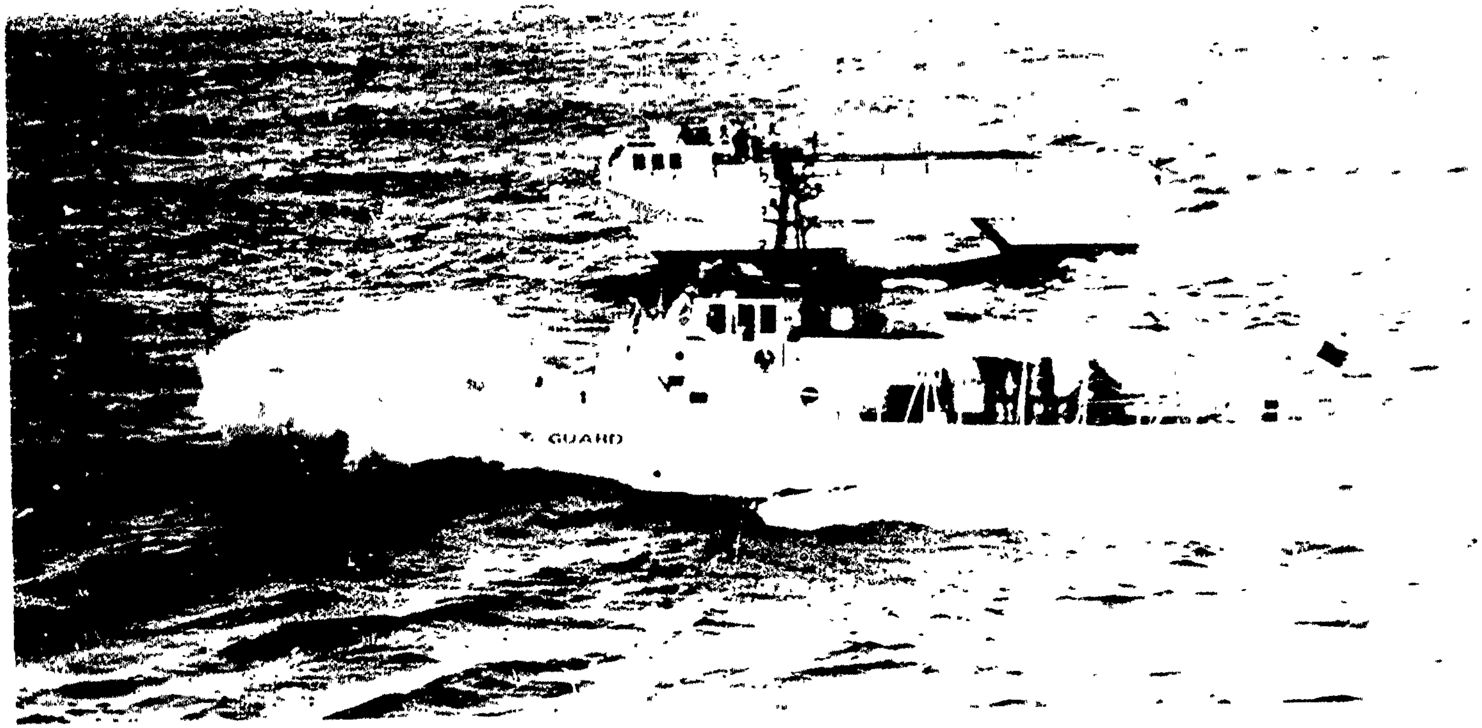


Figure 1-- The 95' WPB Coast Guard Patrol Boat and 89' SSP Semi-Submersible Platform steaming side-by-side respectively.

TABLE 2

GENERAL DESCRIPTIVE CHARACTERISTICS OF TEST VESSELS

Vessel Descriptive Characteristics	SSP	WPB
Length	89'	95'
Beam	47'	20'
Draft	16'	6'
Displacement (tons)	217	100
Hull Type	SWATH	MONO
Design Speed	15-18	12-15
Crew Size	10	17

Procedures

The experiment was conducted over a three day period. The first day was spent at dockside to determine baseline levels of the psychomotor performance, physiological and affective state data. The remaining two days were spent at sea where the WPB and SSP steamed in formation at 7 knots over a course shown in Figure 2.

The vessels left port at 0700 on the morning of the first steaming day and traveled to their initial starting position. At 0800 the vessels began to steam along a prescribed course designed to sustain and replicate motion environments for the subjects between days at sea. At the same time the steaming course permitted the return of the vessels to port shortly after completion of testing on the second steaming day.

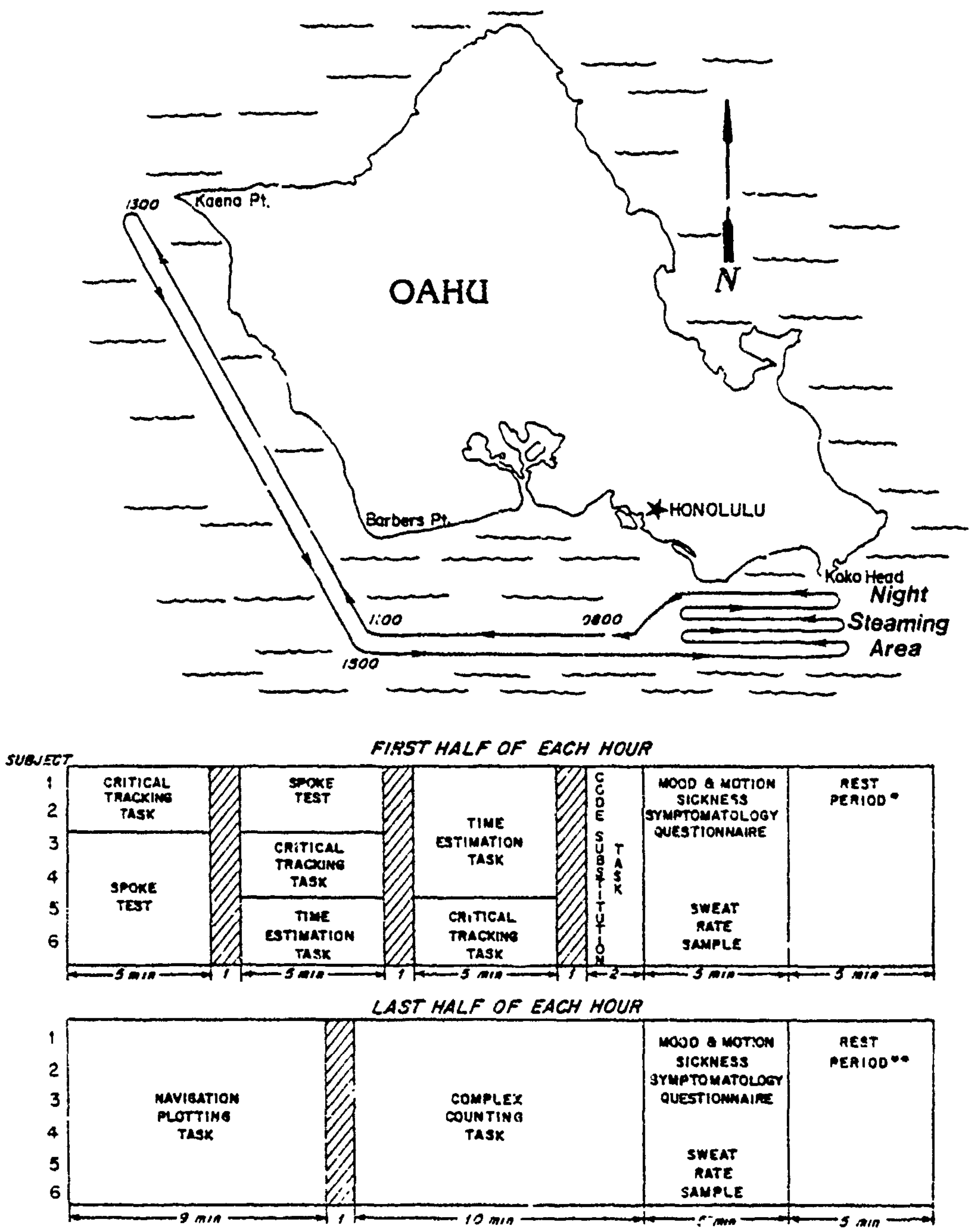
Data collection began at 0800 each day and continued, a described in Figure 2, until 1600 each day. Upon completion o testing each day subjects were provided supper and instructed to rest for the next day's testing. Subjects were randomly assigned to each vessel for the duration of the experiment and remained aboard the vessels to insure compliance with dietary and rest requirements.

While performing tasks subject electrocardiogram (ECG) records were made continuously using Beckman standard biopotential electrodes. The records were made using a three-lead procedure described by Goldman (1975).

Sweat rates were sampled every thirty minutes as shown in Figure 2 using preweighed sealed absorbent fiber pads placed upon the subjects' foreheads under athletic sweat bands. After three minutes, the pads and sweat bands were removed, the pads returned to their airtight containers, and reweighed later to determine the volume of sweat absorbed per unit area and time.

Total void urine specimens were collected every two hours during data collection periods after disgarding the morning's urine just prior to 0800. Each specimen was collected in a seperate twenty-four hour urine specimen container, acidified with 6 ml of 6N HCl and stored in ice chests for analysis upon returning to port or upon completion of testing during the dockside day.

Urine specimen volume, specific gravity, total catecholamine



*Subjects drank 240 ml of water or highly diluted punch

**Subjects drank 240 ml of water or highly diluted punch and provided total void urine specimens at 1000, 1200, 1400, and 1600 each day

Figure 2. Data collection paradigm.

and 17-OHCS levels were determined for individual two-hour samples. Volumes were measured to the nearest milliliter (ml) using a graduated cylinder while specific gravities were determined with a clinical hydrometer. Total catecholamine levels were radio-enzymatically assayed to the nearest tenth of a microgram using a modified Passon and Peuler (1973) technique. Levels of 17-OHCS in the urine were colormetrically determined to the nearest tenth of a milligram (mg) using the Porter-Silber (1950) method.

All subjects shared the same diet in which no fluids or solid foods containing caffeine or alcohol were permitted. Restriction of stimulants and alcohol was enforced forty-eight hours prior to data collection. The morning meal was completed one and a half hours before data collection and food was provided to the subjects during the testing on demand during their five minute breaks throughout the day. To insure adequate hydration and urine production, all subjects drank 240 ml of water, or a highly diluted punch, every thirty minutes.

Motion sickness symptomatology and affective state were sampled after the first twenty minutes of each thirty-minute period using a combined mood adjective check list (MACL) and motion sickness symptomatology severity (MSSS) questionnaire (see Appendix D). Mood adjective checklist responses were scaled and scored according to Nowlis and Nowlis (1956) and motion sickness symptomatology according to Wiker et al. (1979).

The performance task battery consisted of six seperate tasks (e.g. navigation plotting, code subsitution, complex counting, critical tracking, Spoke test, and time estimation). The sequence of administration of these tasks is provided in Figure 2.

The navigation plotting task is an operationally based task of nine minutes in duration, Subjects were provided a test sheet containing a series of printed relative position reports of a "target vessel". From the position reports subjects progressively plotted the movement of the target vessel using a pair of forty-five degree triangles, a compass and a standard maneuvering board (H. O. 2665-20).

Relative course, speed, and closest point of approach of the target vessel were plotted, measured, computed and recorded on the test stimulus sheet in appropriate boxes. Subjects were instructed to complete accurately as many problems as possible. Results were scored for total number completed and total number correct.

The complex counting task required subjects to listen to three different tones (100, 900 and 1800 Hz) which were presented in a quasi-random fashion for a ten minute period via a cassette tape recorder (Kennedy and Bittner, 1978). Each subject was instructed to listen to and mentally keep track of the number of occurrences of each tone. Upon reaching a count of four for any one of the three tones, the subject noted the event by pressing an appropriately coded button. The button transferred the event onto FM magnetic tape for later analysis. Once pressing a button the subject reset his "mental count" for that particular tone and continued the procedure until told to stop.

Time intervals between button presses served as the scoring measure and the percent of correctly counted quartets of the lowest tone was used in data analysis.

Critical tracking task (CTT) performance was investigated using a Systems Technology Inc. Mk-8A Critical Task Tester. Each subject was required to monitor and track a needle within the center of a meter-type display. To accomplish this task, compensatory corrections against random needle movements were made via a freely turning control knob located beneath the meter display. Eventually, as the needle was made increasingly unstable, the limit of the subject to effectively control or nullify the needle movement was reached and the needle disappeared, ending the trial. The resultant score was displayed digitally indicating the critical tracking limit, or oscillation bandwidth (λc), at which the subject could no longer effectively track. Five trials were completed during each test. The median score was used for analysis to minimize spurious biodynamic interference contribured by the vessel's motions at sea. Subjects were also encouraged to take measures necessary to reduce biodynamic interference during the trial.

Code substitution tests were administered to subjects for a period of two minutes during each hour was depicted in Figure 2. During the allotted time, subjects substituted a numeric array for an alpha array using a coding matrix provided at the top of the stimulus sheet. Scores were based upon the number of substitutions completed. Earlier investigations had found error rates with this task to be minimal (Wiker and Pepper, 1978;

Wiker et al., 1980).

The Spoke test consisted of s stimulus sheet on which a circle 24 cm in diameter was surrounded by a series of similar circles which were equidistant from the center and evenly distributed along the periphery. Thirty-two numbers, 1-32, were randomly located in each of the peripheral circles. Upon the command to start, subjects were to move a pencil point from the center circle to that peripheral circle containing the number "1" and return to the center circle. This process was repeated in numerical order as quickly as possible until the subject had located and marked all 32 numbers. Upon completion of this "experimental" task the subject was then told his time of completion and the time logged.

The "experimental" trial was followed by a "control" trial in which subjects moved their pencil points from the center circle to each successive peripheral circle and back again until all 32 circles had been progressively tapped in a clockwise manner. The completion time was read to the subject and logged.

Three performance scores were obtained from the Spoke test; a Spoke (experimental) completion time, a Spoke (control) completion time and a Spoke (difference) time which represented the difference between the experimental and control trial completion times. The Spoke (difference) score was intended by Kennedy et al., (1979) to provide a better index of visual search and information processing time requirements by subtracting out the motor component of the task.

The time estimation test used in this study was based on the method of production. A list of time intervals to be produced, ranging from 2 to 12 seconds, was provided on a test sheet. Subjects attempted to produce a given time interval by pressing a key. The key presses were automatically time coded and recorded on magnetic tape for later analysis. The subjects were allowed to count subvocally. No feed back information was given to subjects about the accuracy of their estimates.

A single administration of the time estimation tests included a total of 40 trials, randomly ordered, consisting of five sets of the following eight time intervals: 2,3,5,6,8,9,11 and 12 seconds. The test was administered every half-hour.

Scoring of the time estimation test was done by comparing the actual duration of the subject's estimate with the desired time interval. Problems in retrieving and decoding the data from the magnetic tapes permitted analysis of only the 12 second interval.

Performance test materials were appropriately randomized to eliminate unwarranted learning and other sequence effects.

Upon completion of testing subjects were debriefed using questionnaires (see Appendix C).

RESULTS

Sound pressure level recordings made while the vessels were underway are provided in appendix E.

Testing compartment dry bulb temperature and relative humidity readings made during data collection periods are provided in appendix F. A one-way analysis of variance (ANOVA) test was conducted between daily recordings made aboard each vessel. The results show that there were no significant differences between vessels in either temperature or relative humidity during the data collection periods at sea. The SSP's testing compartment was slightly warmer than that of the WPB during the dockside period ($p < .05$). Damage to the hygrometer aboard the WPB during the dockside testing day precluded a comparison of the relative humidities between vessels.

Results of spectral analyses of test compartment and vessel center of gravity motions data for each vessel are provided elsewhere (Woolaver and Peters, 1980). One-way ANOVA tests were performed on daily test compartment motion measures to determine if significant differences existed in the vessel motion environments during data collection at sea. The results of these tests, along with summary plots of test compartment linear accelerations data, showed that the WPB produced a more dynamic testing environment than did the SSP at sea.

No objective records of sea state conditons were made in this study. However, comparison of the test compartment motions records of this study, and a previous study in which the same vessels steamed at similar speeds through a measured sea state 3 conditions (Wiker et al., 1980), indicate that sea state 3 or lower sea conditions were experienced.

Inspection of the time series plots of test compartment motions data show that the motion environments endured by the subjects were comparable between steaming days. During the morning hours, when the vessels steamed in the lee of the island and seas were calm, the test compartment motions were small. Near midday, the vessels steamed out of the lee of the island and encountered small but noticably larger waves from the starboard bow. At midafternoon the vessels reversed course, steamed with the seas, and returned to the lee of the island.

Two sets of analyses were performed to determine the effects of each vessel's motion environment at sea upon physiological, mood and performance measures. First, a one-way ANOVA test was performed to determine if there were significant differences in the aforementioned variables between dockside and steaming day periods. The results of these analyses are cited in the following text. Second, a three-factor unweighted means ANOVA was conducted on steaming day data to determine if differences existed between vessels, steaming days and time of day over the two day period. Summary tables for the three-factor ANOVAs are in appendix I

Physiological Measures:

Comparisons between dockside and steaming day MSSS scores showed no significant differences for either the WPB ($F(1,182) = 0.1$, $p > .05$) or the SSP ($F(1,222) = 1.3$, $p > .05$). Analysis of MSSS scores during steaming days showed that motion sickness severity was greater aboard the WPB than that found aboard the SSP ($p < .05$).

Motion sickness severity declined from the first to second day at sea ($p < .01$). A significant ship by day interaction shows that the decline in motion sickness severity from the first to second day at sea was greatest aboard the WPB ($p < .05$).

Figure 3 on the following page illustrates a general increase found in motion sickness severity as the day progressed ($p < .001$). The vessels steamed in relatively calm waters in the morning hours, however, in the afternoons vessel motions increased when the vessels steamed out into unprotected waters.

Changes in MSSS scores did not vary significantly from day to day in their hourly patterns within the vessels.

It should be noted that of the five subjects aboard the WPB not one escaped vomiting during the first steaming day. There were ten episodes of vomiting aboard the WPB during the first steaming day. However, during the second day at sea no subject vomited aboard the WPB. No subject vomited aboard the SSP during either steaming day.

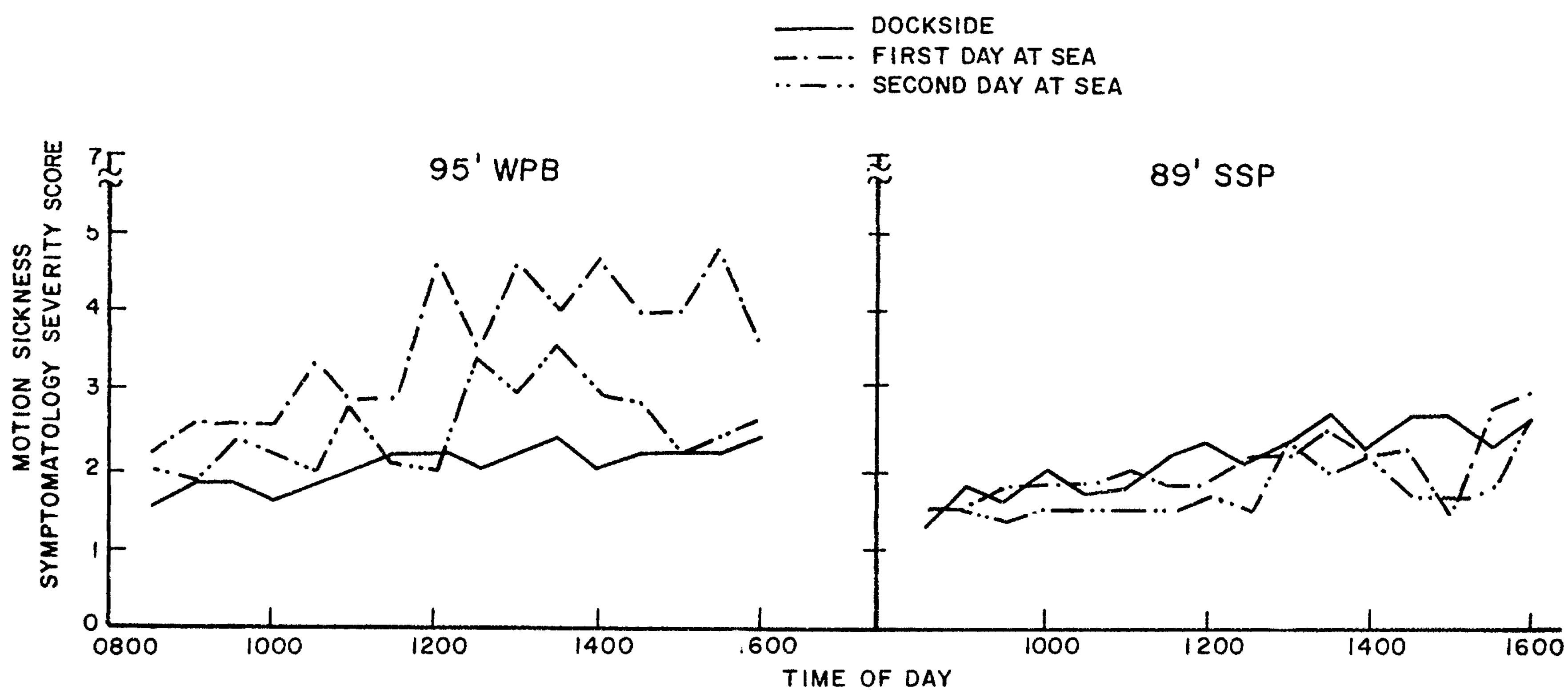


Figure 3. Half-hour means of motion sickness symptomatology severity (MSSS) scores plotted as a function of vessel class, test day and time of day.

A 41.0 percent decline in urine output was found from dockside to steaming periods in subjects aboard the WPB ($F(1,46) = 5.7$, $p < .05$). No significant differences in urine output were found with a similar comparison of data from the SSP ($F(1,62) = 2.7$, $p > .05$).

No differences were found in urine output between vessels during the steaming period. Urine output did increase 31.7 percent from the first to second day at sea ($p < .05$). There were no significant differences between vessels in the rate of increase in urine output from the first to second day at sea.

As shown in the following figure, there were significant variations in urine output across time during the days at sea ($p < .001$). The increase in urine output during the morning and late afternoon periods and reductions during rough water periods at midday were more pronounced aboard the WPB than aboard the SSP ($p < .01$).

There were no significant differences in the daily pattern of urine output from the first to second day at sea.

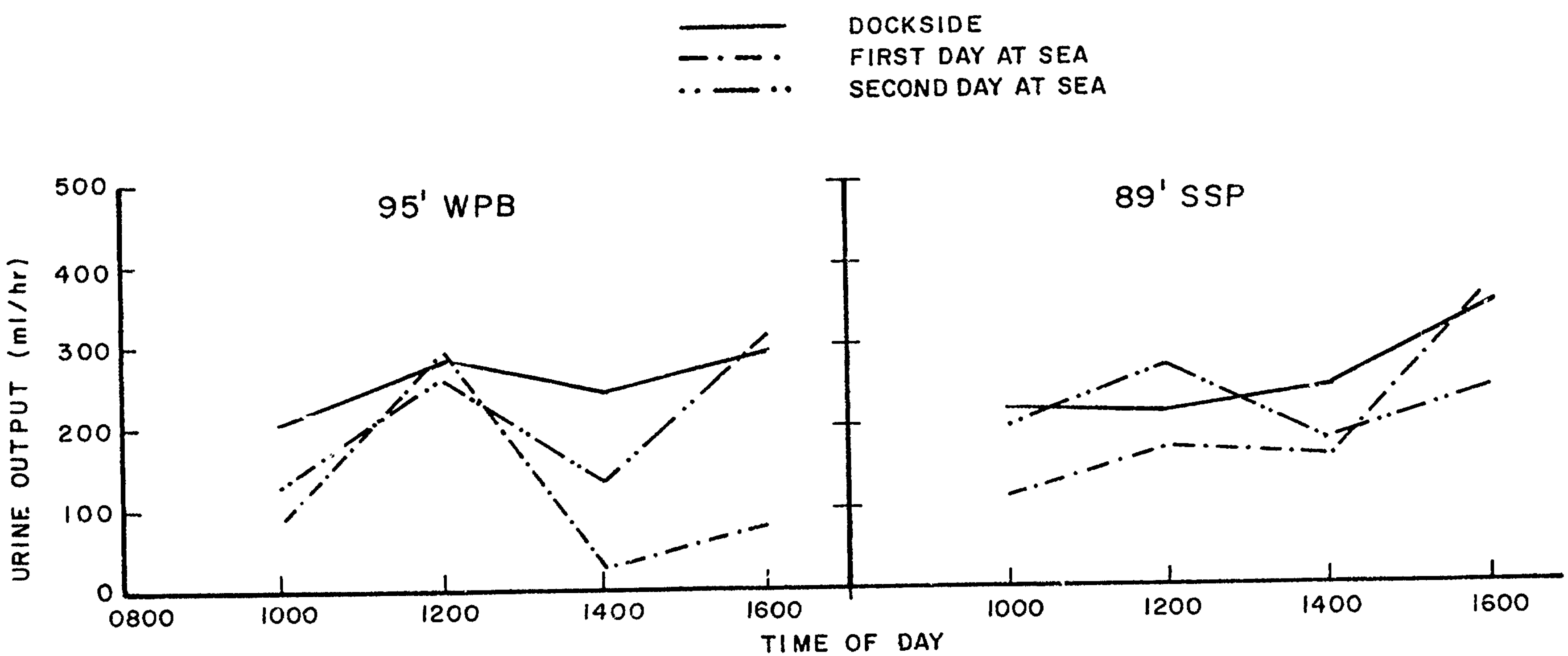


Figure 4. Two-hour means of urine output plotted as a function of vessel class, test day and time of day.

Comparisons between dockside and steaming periods of urine specific gravity levels showed that there were no significant differences within either the WPB ($F(1,42) = 3.0$, $p > .05$) or the SSP ($F(1,62) = 3.4$, $p > .05$).

Analysis of specific gravity data collected at sea showed that there were no significant differences between the vessels over the two day period.

Specific gravities did decline from the first to second day at sea. The rate of decline over the two days at sea was not significantly different between the vessels.

Specific gravity levels changed as the data collection periods progressed at sea ($p < .01$). As shown in the following figure, specific gravities generally declined during the day spent at dockside. A similar pattern was found aboard the SSP at sea as the days progressed. However, significant elevations in urine specific gravity were found aboard the WPB at sea during periods of greater vessel dynamics and increased motion sickness severity.

No significant day by hour interactions were found.

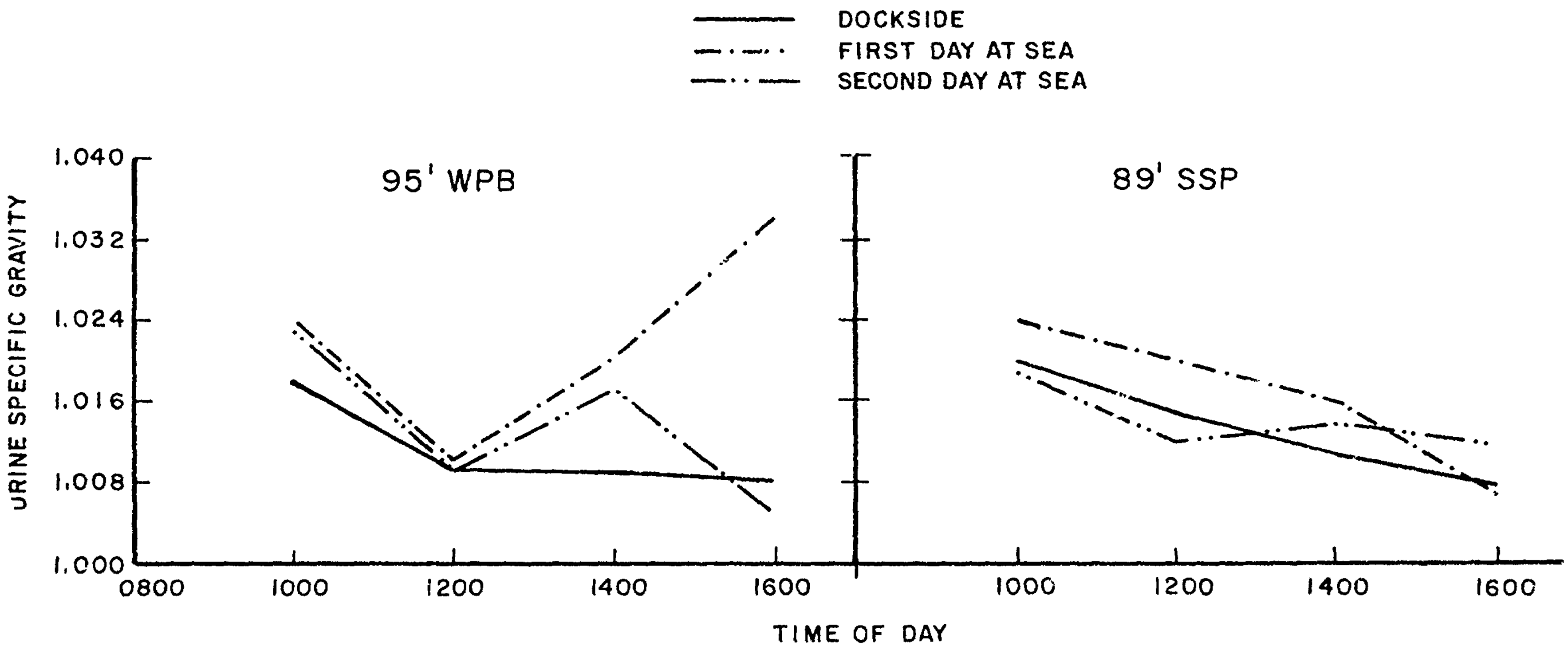


Figure 5. Two-hour means of urine specific gravity levels plotted as a function of vessel class, test day and time of day.

Two-hour samples of 17-hydroxycorticosteroid excretion in subjects aboard the WPB showed a 23.2 percent decline from dockside to steaming day periods ($F(1,46) = 5.2$, $p < .05$), however, no differences were found with a similar analysis of the SSP data ($F(1,62) = 0.5$, $p > .05$).

No significant differences were found in 17-OHCS excretion rates between the vessels at sea. There also were no differences in excretion rates between days spent at sea.

Variations in 17-OHCS excretion rates across steaming days were not found to be significantly different between vessels.

No signficant variations were found in excretion rates of 17-OHCS as the days progressed at sea. All interactions between vessels, steaming days and time of day were found to be insignificant. See figure 6.

No significant differences were found between dockside and steaming periods within either the WPB ($F(1,46) = 1.1$, $p > .05$) or the SSP ($F(1,61) = .59$, $p > .05$) catecholamine excretion.

No differences were found in catecholamine excretion rates between vessels during the period at sea. No differences in excretion rates were found between the two days at sea as well.

Although figure 7 indicates there might be differences in catecholamine excretion rates as the days progressed at sea, no statistically significant differences were found due to large variations in the data. Additionally, no significant interactions were found between vessel, day and time of day effects in the data collected at sea.

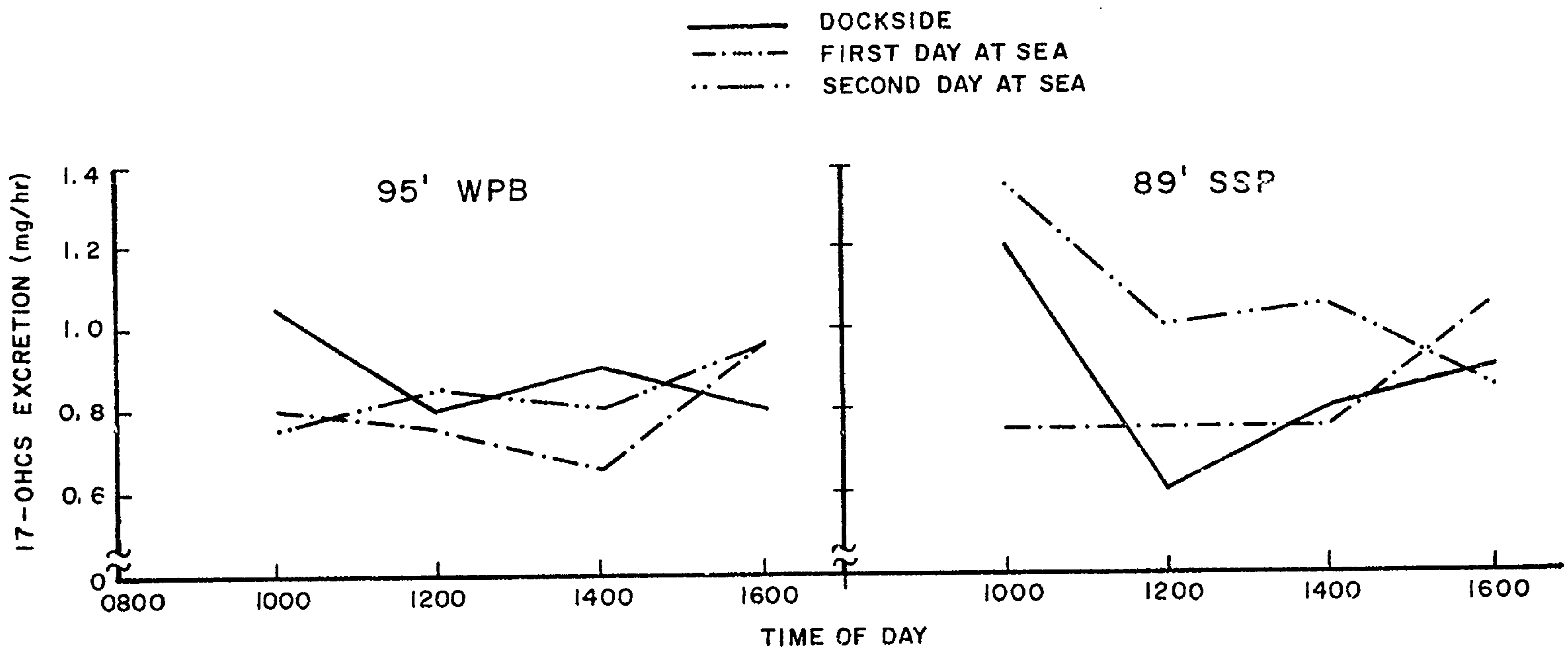


Figure 6. Two-hour means of urinary excretion of 17-hydroxycorticosteroids as a function of vessel class, test day and time of day.

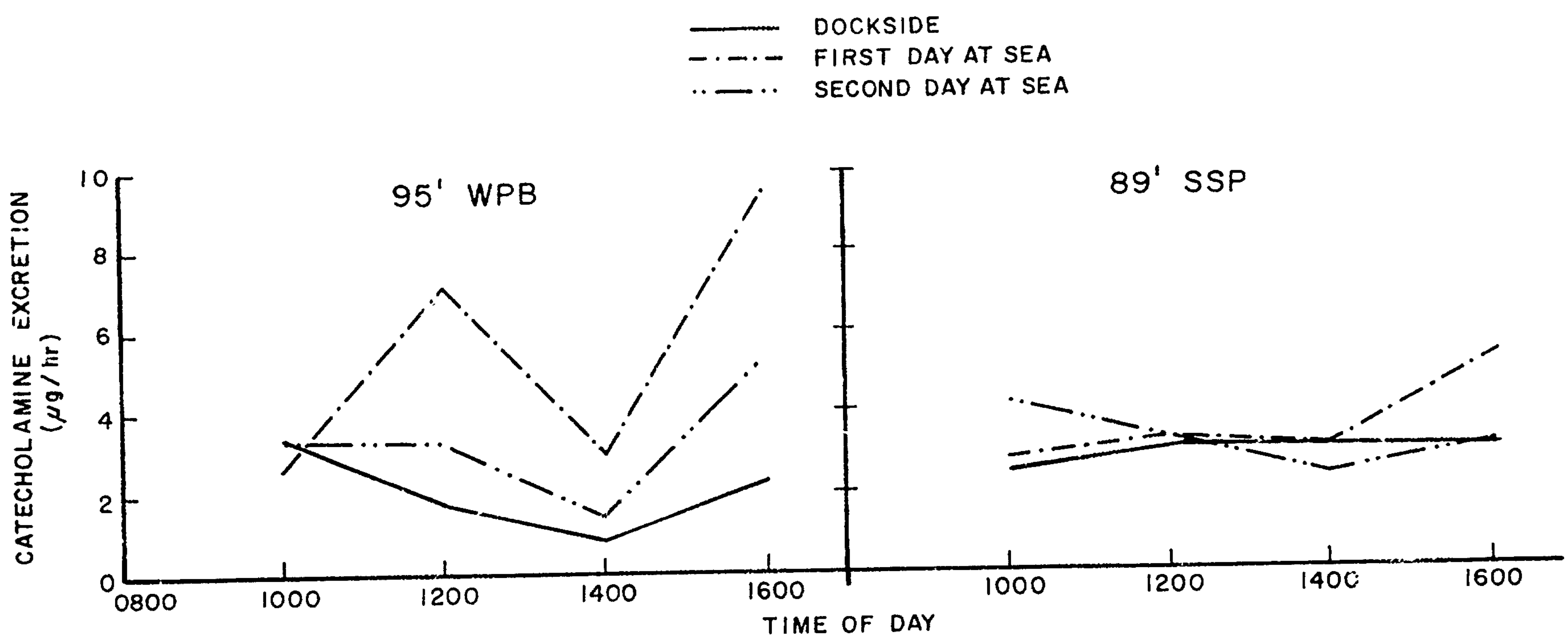


Figure 7. Mean excretion rates of catecholamines as a function of vessel class, test day and time of day.

Heart rates increased from dockside to steaming periods by 16.3 percent aboard the WPB ($F(1,182) = 46.9$, $p < .001$) while no changes were found aboard the SSP ($F(1,325) = 1.8$, $p > .05$). Differences between vessels at sea were not significant.

An increase of 3.0 percent was found in heart rates from the first to second day at sea ($p < .05$) but no significant differences were found in the rate of increase between vessels.

A general decline in heart rate was found at sea as the day progressed ($p < .001$), with declines more pronounced aboard the WPB ($p < .001$).

Figure 8 shows that there was a significant variation ($p < .01$) in the progression of heart rate during the two days at sea aboard the SSP. On the first day at sea subjects aboard the SSP exhibited a gentle decline in rates as the day progressed, however, during the second day at sea heart rates showed a gentle increase over time.

No increases in sweat rates were found between dockside and steaming day periods aboard either the WPB ($F(1,119) = 0.7$, $p > .05$) or the SSP ($F(1,147) = 2.4$, $p > .05$).

No differences were found in sweat rates between vessels or days during the steaming periods. Changes in sweat rates between ships from the first to second steaming day were also insignificant.

Figure 9 shows that there was an abrupt increase in subject sweat rates aboard the WPB with onset of severe motion sickness during the first day at sea. There was no trend, however, in sweat rates as the days progressed at sea and no significant interaction effects.

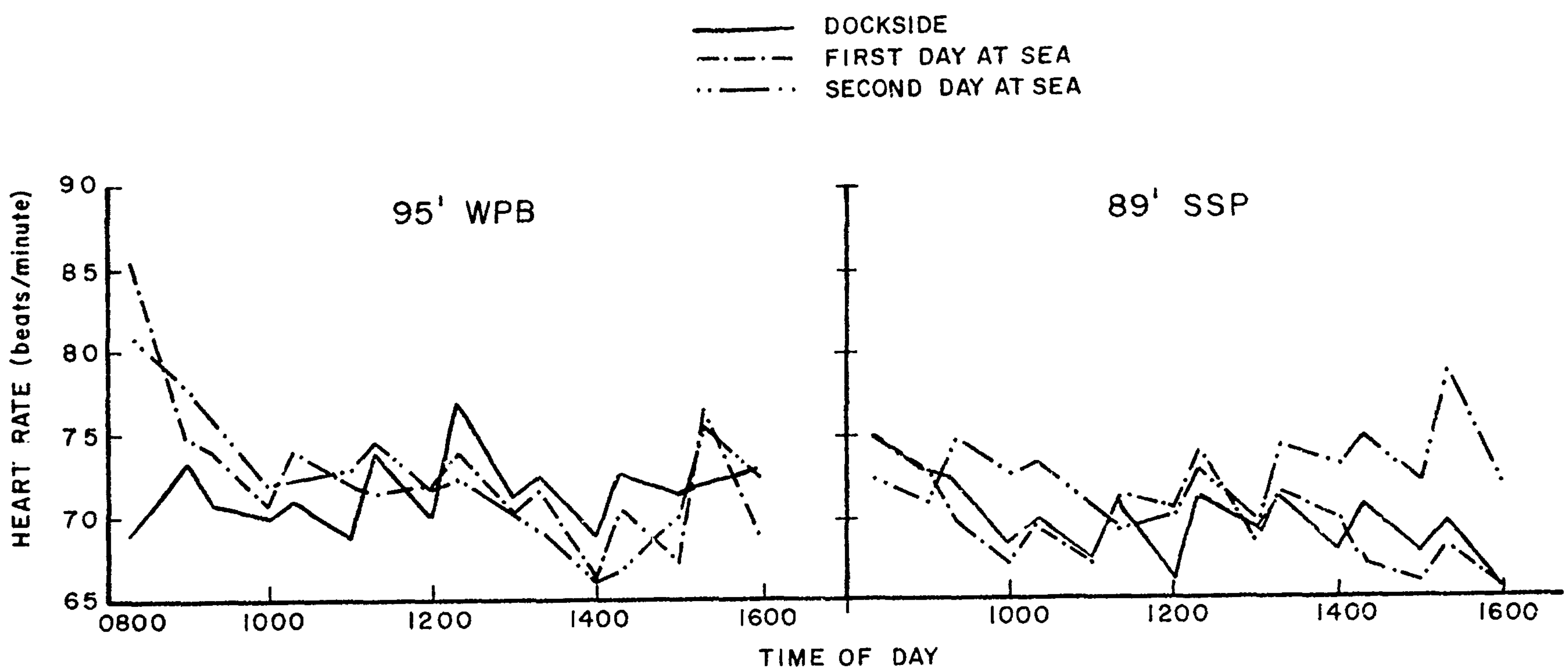


Figure 8. Mean heart rates as a function of vessel class, test day and time of day.

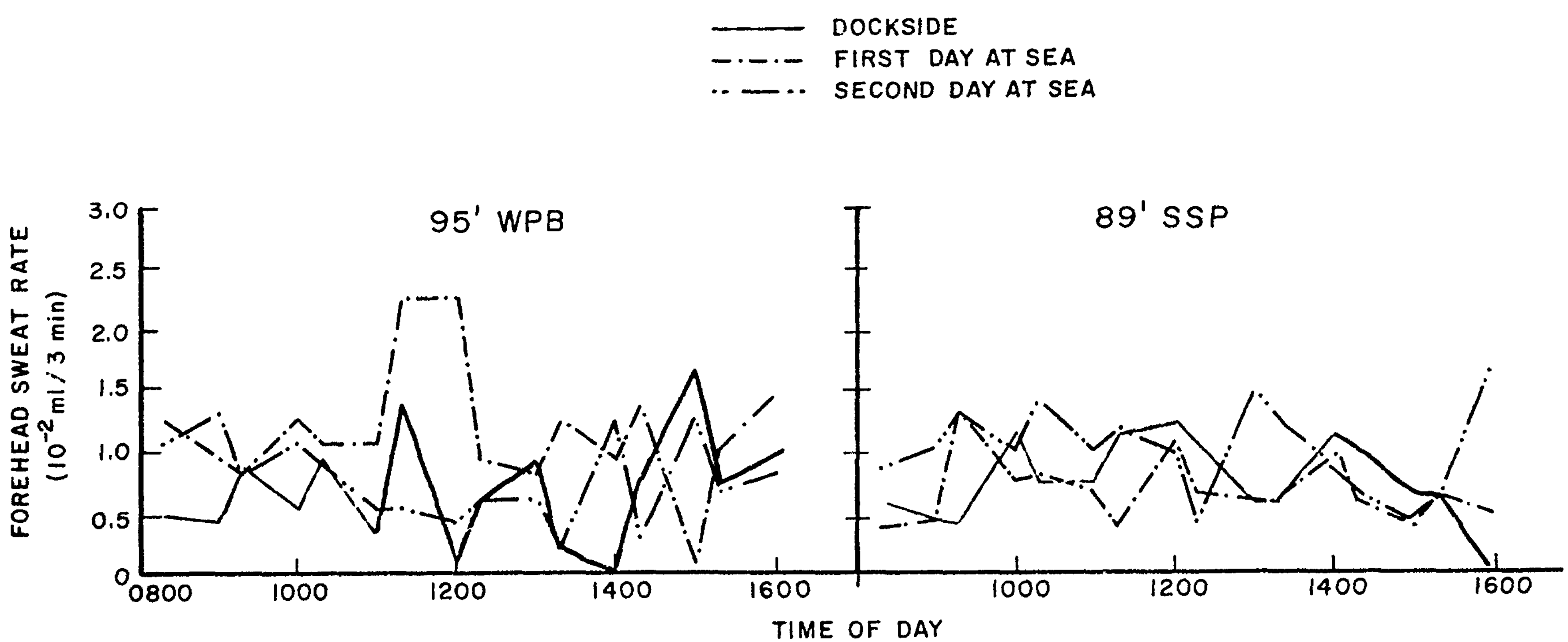


Figure 9. Mean forehead sweat rates plotted as a function of vessel class, test day and time of day.

Affective State Measures

Subject reports of aggression did not increase significantly from dockside to steaming periods aboard the WPB ($F(1,190) = 3.2$, $p > .05$). However, aggression scores increased at sea from dockside levels by 12.9 percent of the score range aboard the SSP ($F(1,254) = 18.5$, $p < .01$).

Analysis of aggression reports collected at sea showed that there were no significant differences between vessels, between days spent at sea, and no significant changes with progression of the testing day.

Interaction effects, with the exception of the vessel by day by hour interaction, were found to be insignificant. See Figure 10.

Means of subject reports of anxiety did not change significantly from dockside to steaming conditions aboard either the WPB ($F(1,190) = 2.2$, $p > .05$) or the SSP ($F(1,254) = 0.3$, $p > .05$). Analysis of reports collected at sea showed that subjects aboard the WPB reported slightly greater levels of anxiety than did subjects aboard the SSP ($p < .05$).

No significant changes in anxiety scores were found from the first to second day at sea. Interaction effects between vessel, steaming day and time of day were also insignificant. See Figure 11.

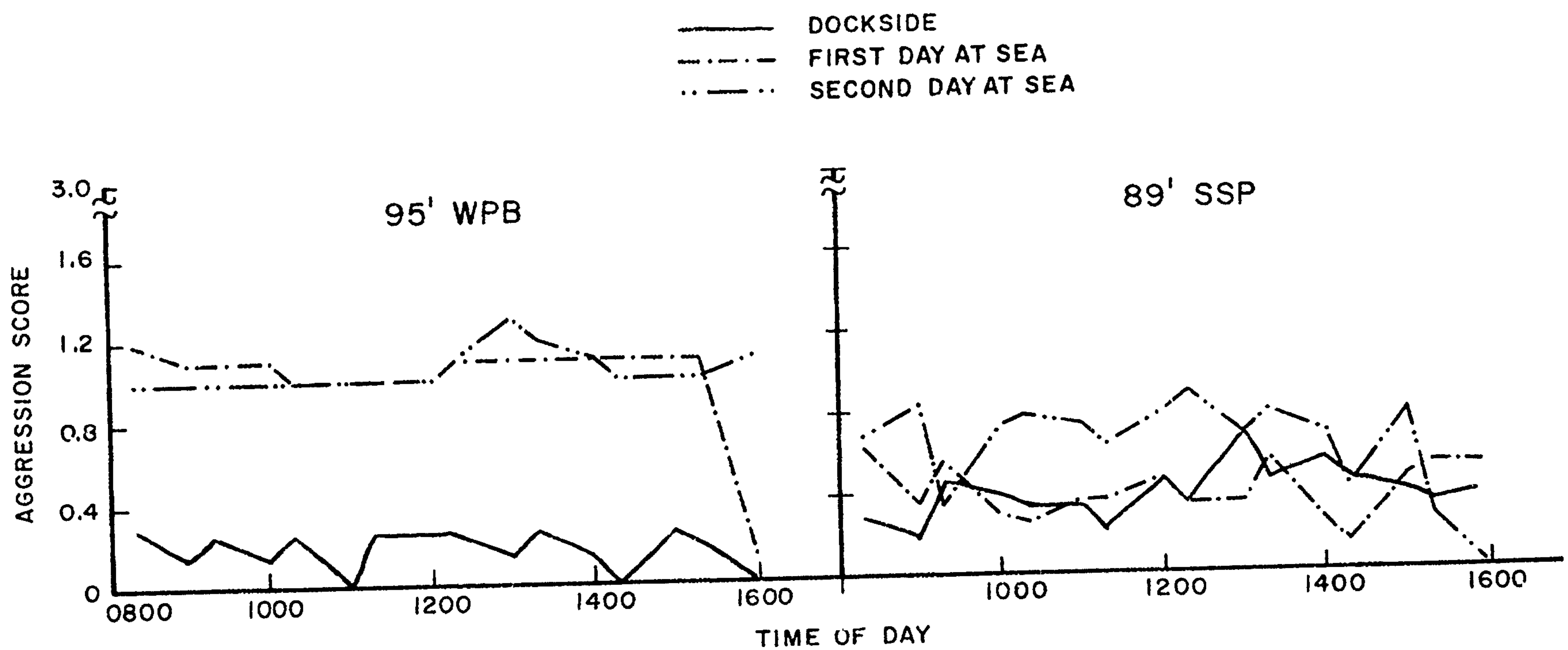


Figure 10. Aggression score means plotted as a function of vessel class, test day, and time of day.

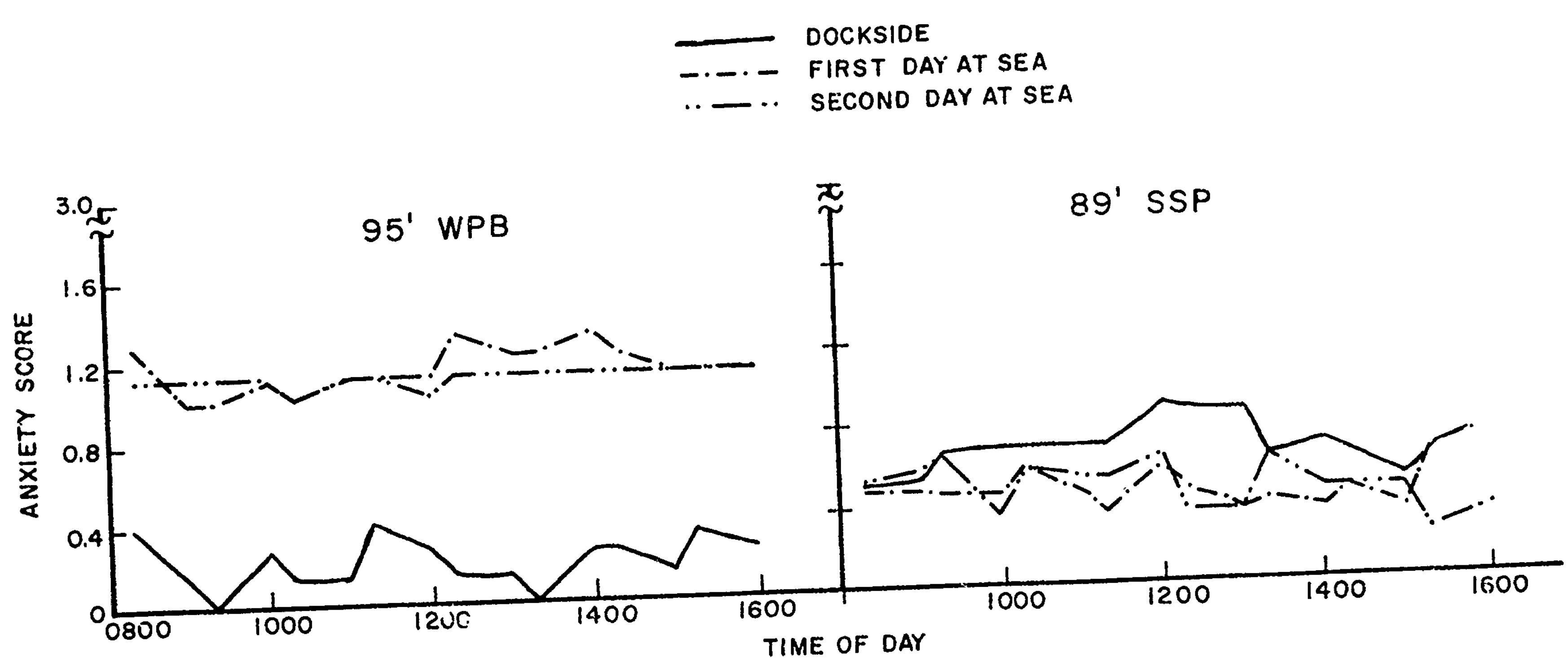


Figure 11. Anxiety score means plotted as a function of vessel class, test day and time of day.

Reports of concentration declined 19.7 percent of the score range from dockside to steaming periods aboard the WPB ($F(1,190) = 26.9$, $p < .001$). No significant changes were found in subjects aboard the SSP ($F(1,254) = 2.2$, $p > .05$).

At sea, no significant differences could be found between the vessels over the two day period.

No significant changes were found in concentration scores across vessels from the first to second day at sea. However, reports did decline gradually across vessels as the day worn on at sea ($p < .01$).

Concentration scores tended to increase aboard the WPB from the first to second day at sea while aboard the SSP scores fell ($p < .05$). No other interaction effects were found to be significant. See Figure 12.

Reports of egotism, or self-concern, increased 39.5 percent of the score range from dockside to steaming periods aboard the WPB ($F(1,190) = 650.3$, $p < .001$). Aboard the SSP egotism scores declined 6.3 percent from dockside to steaming periods ($F(1,254) = 8.6$, $p < .01$).

Data collected at sea showed that reports of egotism aboard the WPB were greater than those from the SSP ($p < .001$).

There were no significant changes in reports of egotism from the first to second day at sea across vessels. No trends were found over time of day at sea either.

No significant interaction effects were found in egotism reports at sea. See Figure 13.

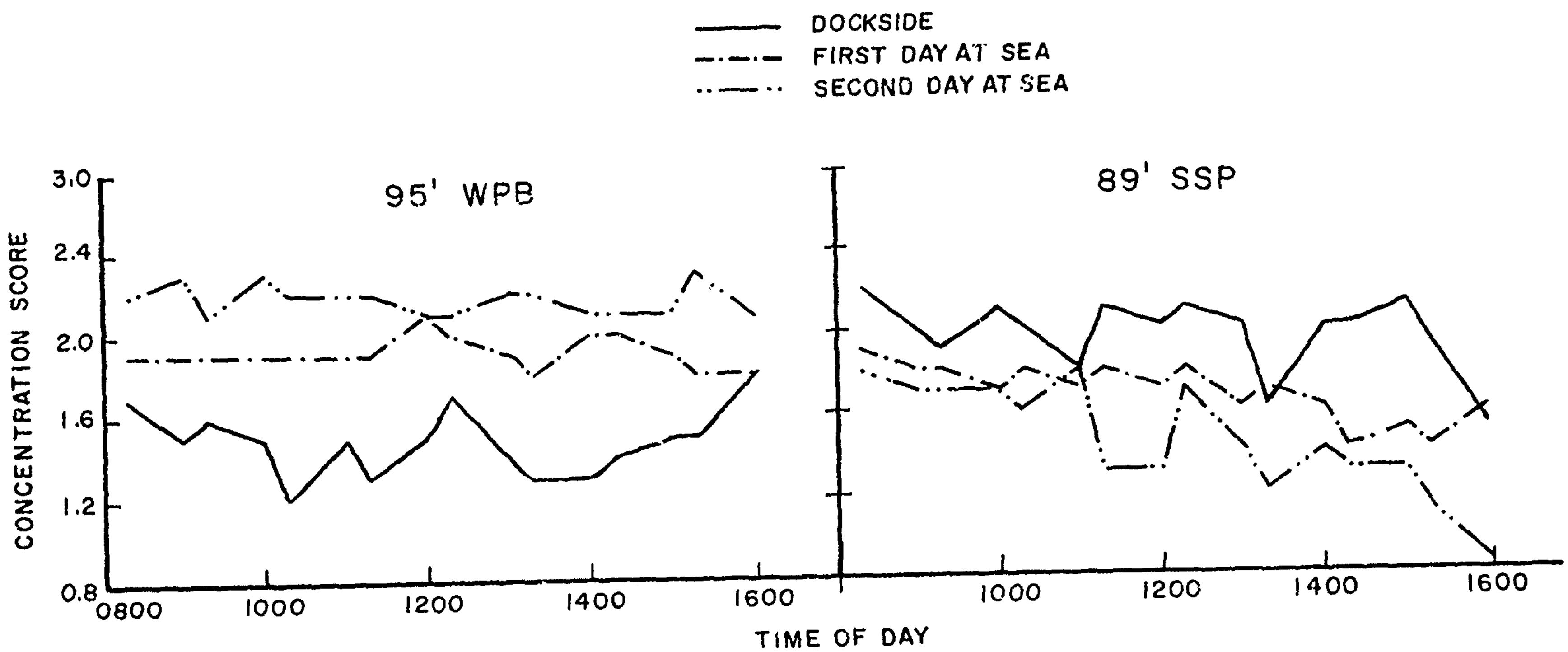


Figure 12. Concentration score means plotted as a function of vessel class, test day and time of day.

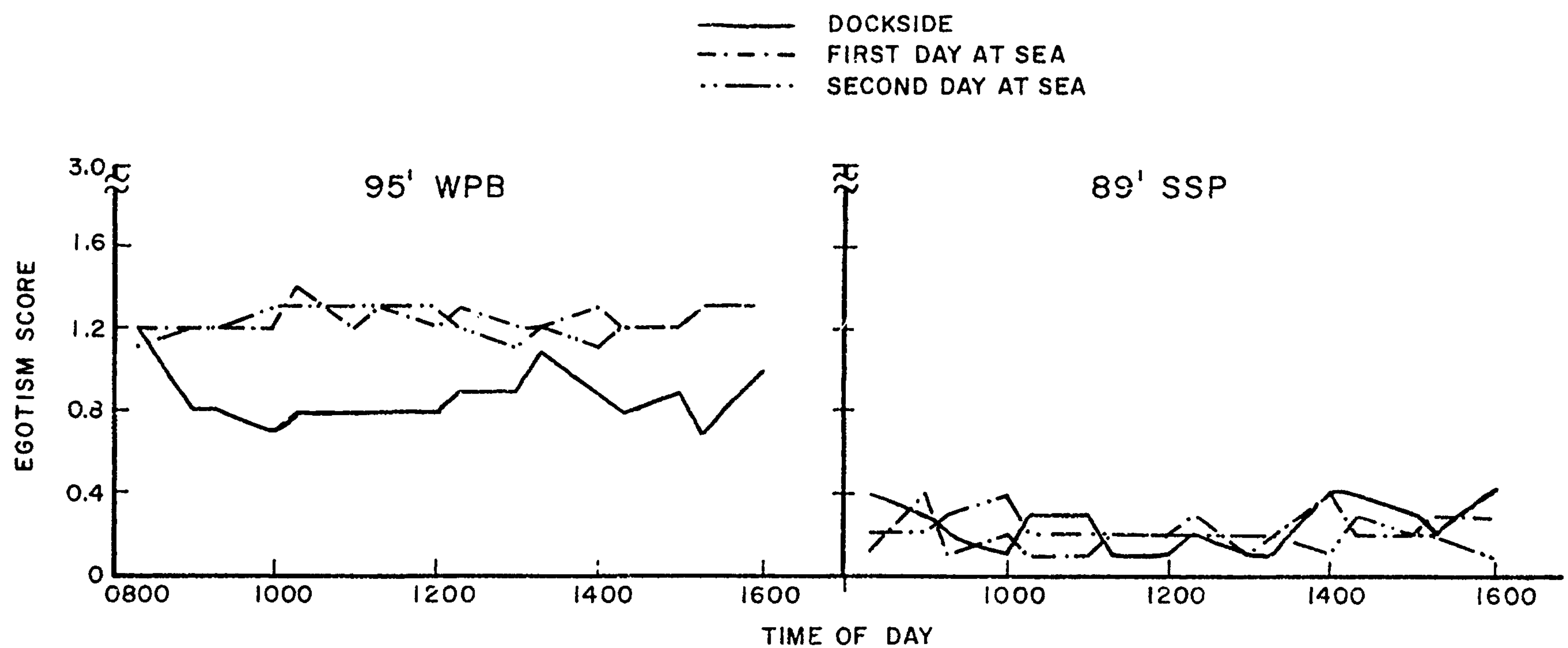


Figure 13. Egotism score means plotted as a .nction of vessel class, test day and time of day.

Reports of elation increased 28.2 percent of the score range from dockside to steaming periods aboard the WPB ($F(1,190) = 230.0$, $p < .001$). No changes were found aboard the SSP ($F(1,254) = 0.8$, $p > .05$).

At sea, reports of elation were slightly greater aboard the WPB than those obtained from the SSP ($p < .01$). No significant changes were found in elation scores from the first to second day at sea across vessels.

Elation scores did abruptly increase near the end of testing days aboard each vessel ($p < .001$). This response was greatest during the last day at sea ($p < .001$).

No interaction effects in elation scores were fourd. See Figure 14.

Reports of fatigue increased 15.0 percent of the score range from dockside to steaming periods aboard the WPB ($F(1,190) = 37.4$, $p < .001$) while no changes were found aboard the SSP ($F(1,254) = 3.2$, $p > .05$).

At sea, no significant differences would be found between vessels over the two day period. There was a slight decline fatigue scores from the first to second day at sea ($p < .05$).

Fatigue reports increased slightly as the day progressed at sea ($p < .001$) with the greatest increase occuring during first steaming day ($p < .05$). No other interaction effects were found to be significant. See Figure 15.

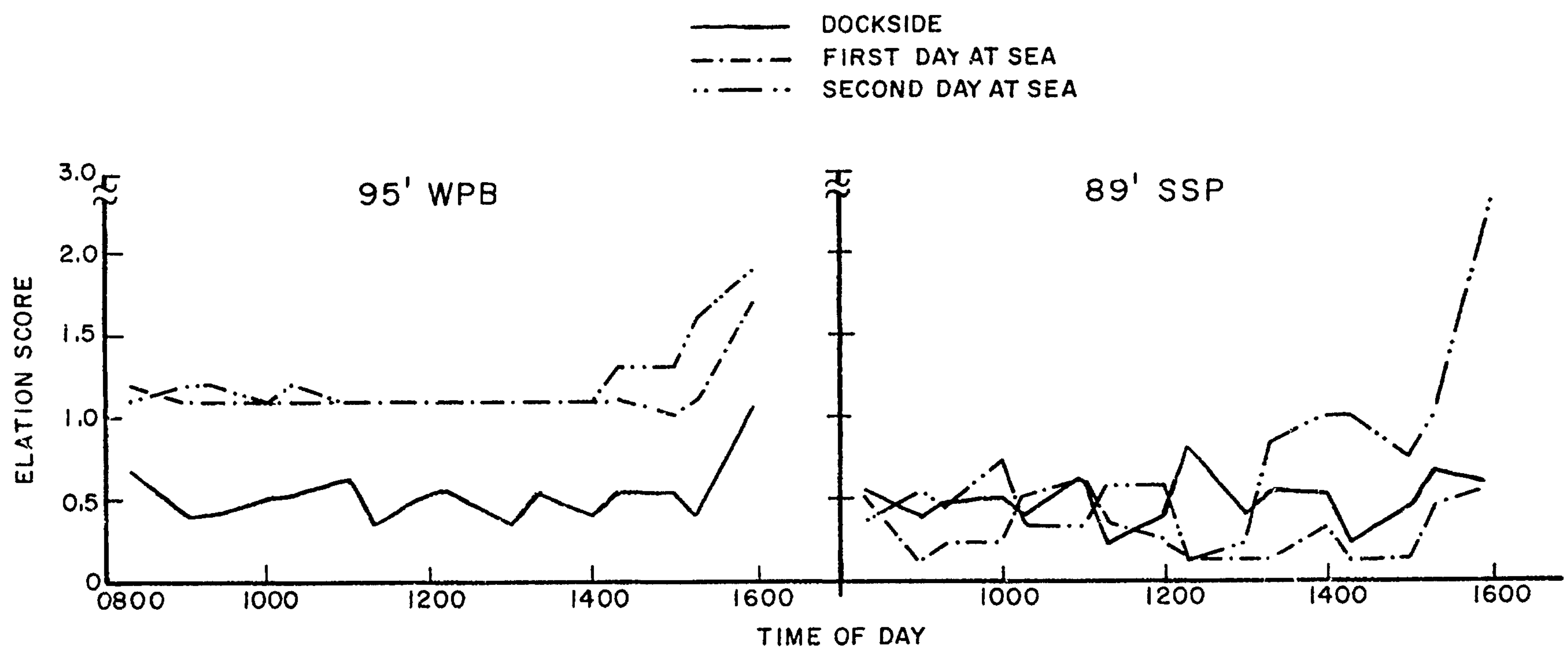


Figure 14. Elation score means plotted as a function of vessel class, test day and time of day.

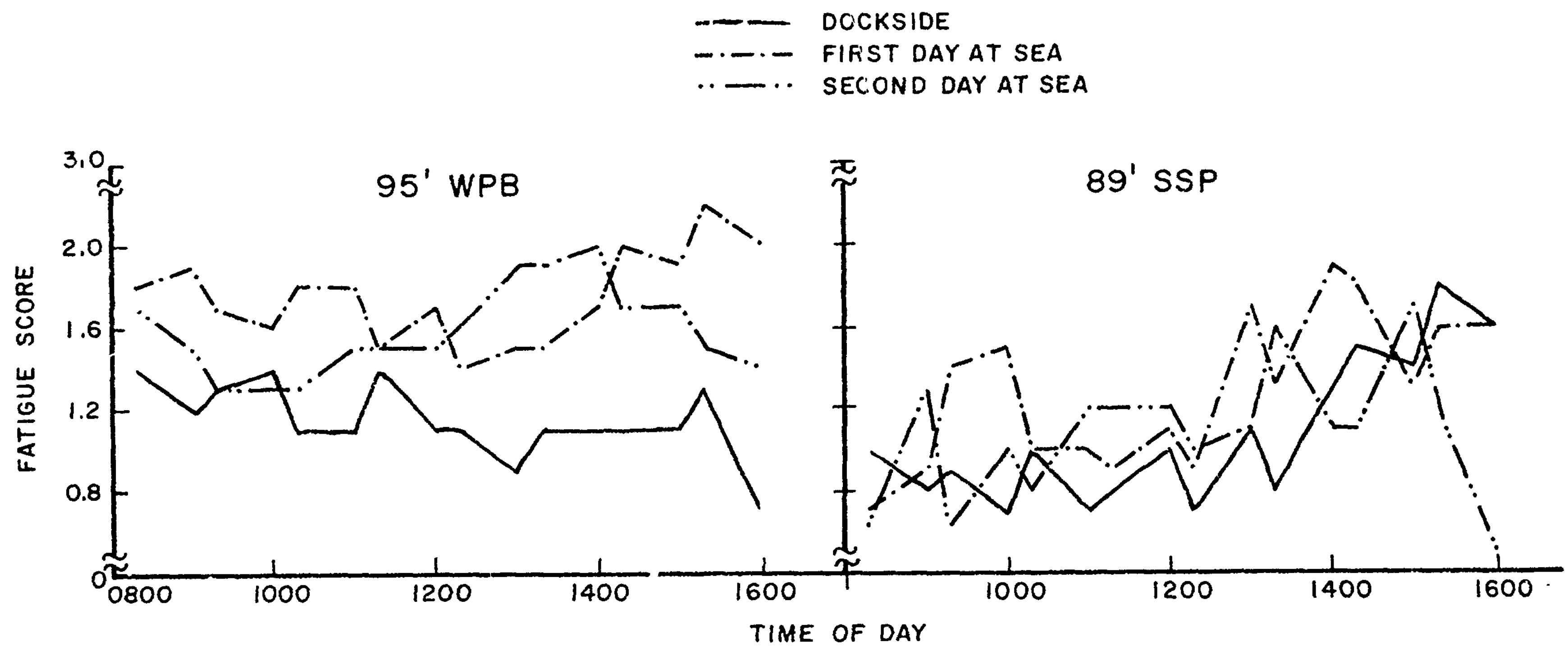


Figure 15. Fatigue score means plotted as a function of vessel class, test day and time of day.

Reports of sadness increased by 38.5 percent of the score range aboard the WPB from dockside to steaming periods ($F(1,190) = 152.5$, $p < .001$) while subjects aboard the SSP reported a 10.7 percent increase ($F(1,254) = 22.0$, $p < .001$).

During the two days at sea reports of sadness were slightly greater aboard the WPB than those from the SSP ($p < .01$). No changes were found in scores from the first to second day at sea across vessels. Furthermore, no significant changes across time or interaction effects were found. See Figure 16.

Reports of skepticism increased by 9.3 percent of the score range from dockside to steaming periods aboard the WPB ($F(1,190) = 9.9$, $p < .01$). Reports increased 9.5 percent in subjects aboard the SSP ($F(1,254) = 11.2$, $p < .01$).

No significant differences in reports of skepticism were found between the vessels over the two day period at sea. Reports across vessels were equivalent between the first to second day at sea.

An abrupt increase in subject skepticism was found aboard the WPB during the first steaming day's onset of severe motion sickness, however, no significant changes in skepticism scores were found throughout the day across vessels at sea.

Aside from a slight differential in reports of skepticism during steaming periods between vessels ($p < .05$) (reports tended to decrease slightly aboard the SSP as the day progressed), no interaction effects were found. See Figure 17.

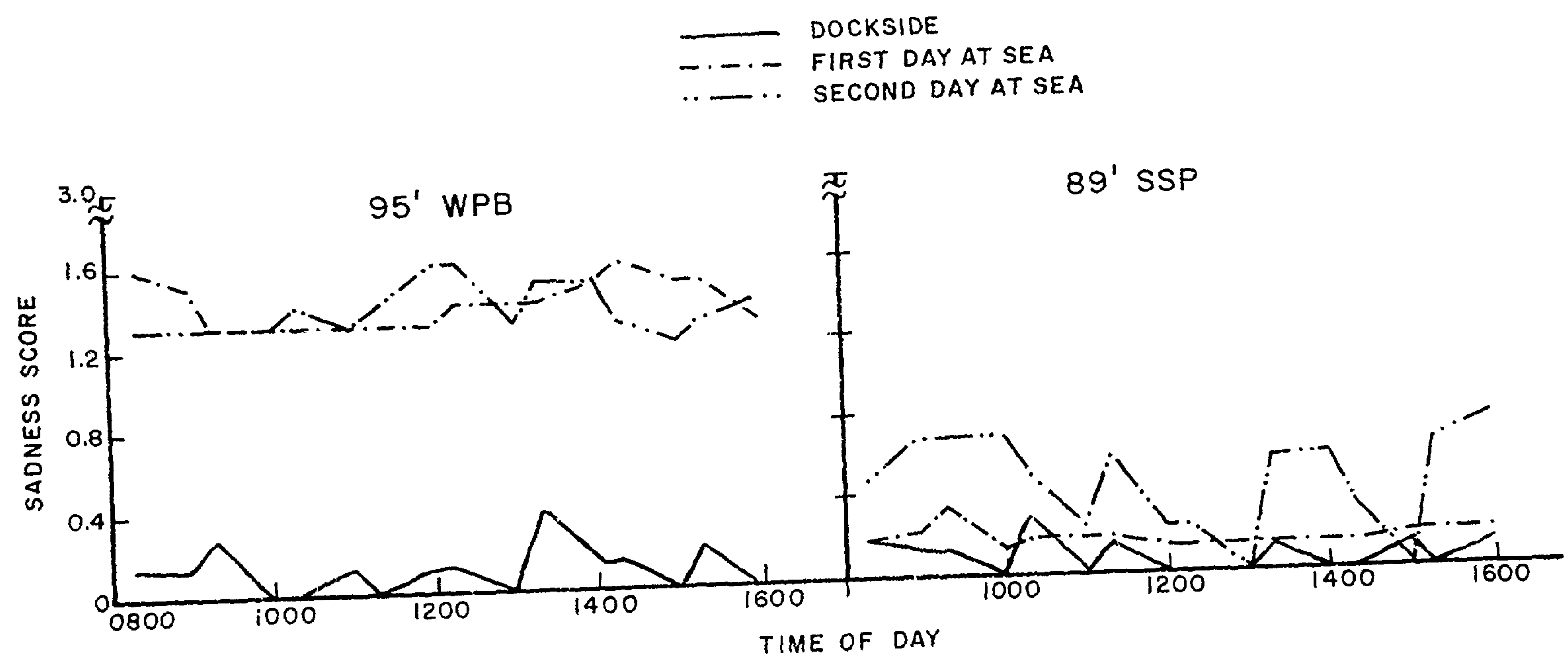


Figure 16. Sadness score means plotted as a function of vessel class, test day and time of day.

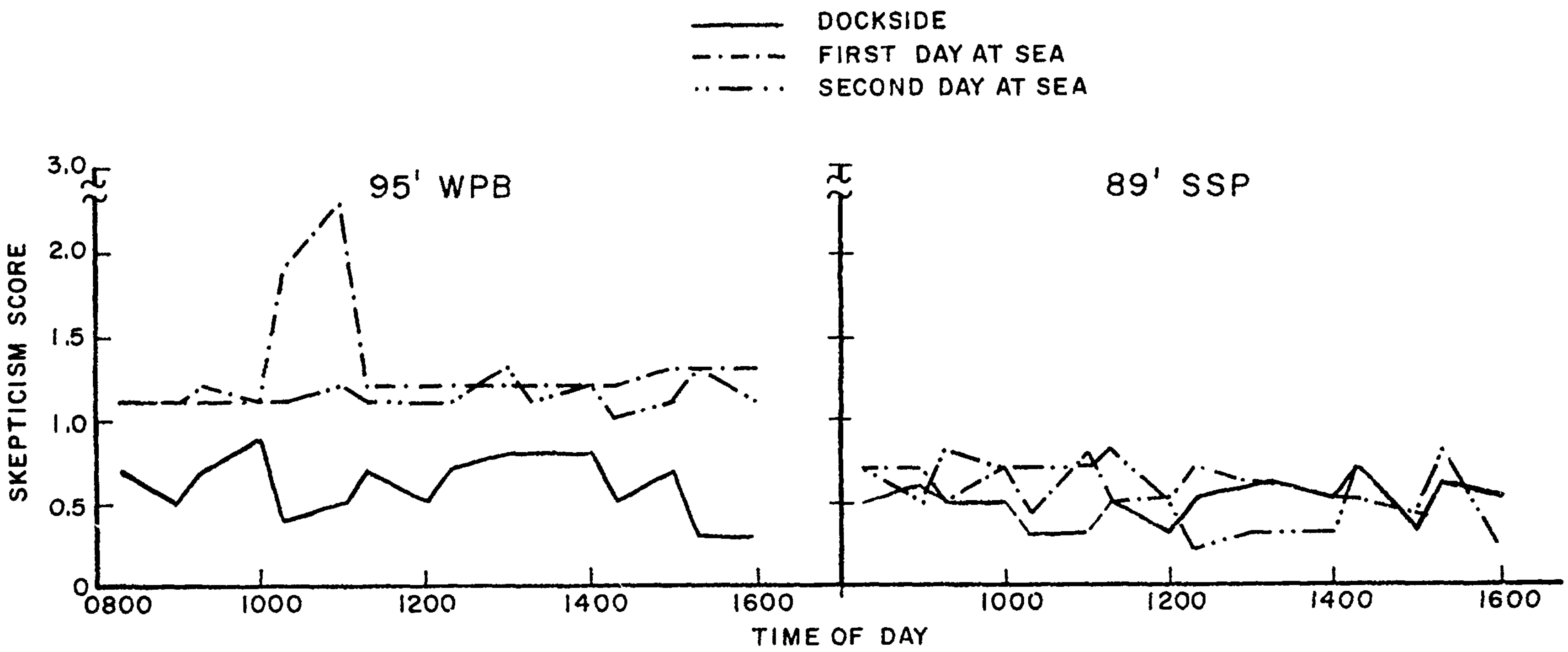


Figure 17. Skepticism score means plotted as a function of vessel class, test day and time of day.

Social affection reports increased by 17.3 percent of the score range from dockside to steaming conditions aboard the WPB ($F(1,190) = 26.7$, $p < .001$). No changes were found aboard the SSP ($F(1,254) = 2.6$, $p > .05$).

At sea, social affection scores were slightly greater aboard the WPB than those obtained from the SSP ($p < .05$). Reports did not change significantly between the first and second days at sea across vessels.

No changes were found in subject reports of social affection over time of day at sea, however, a very small increase in scores was found during the day across vessels and testing days ($p < .01$). No other interaction effects were found. See Figure 18.

Surgency reports increased by 32.3 percent of the score range from dockside to steaming periods aboard the WPB ($F(1,190) = 271.9$, $p < .001$) while no changes were found in subject aboard the SSP ($F(1,254) = 2.8$, $p > .05$).

Reports of surgency increased slightly from the first to second day at sea across vessels ($p < .05$). As shown in Figure 19, this increase was primarily aboard the SSP.

No significant trends in surgency scores were found over time of day at sea. However, during the second steaming day, surgency reports increased at a slightly greater rate aboard the vessels than was found during the first day at sea ($p < .01$). No other interaction effects were found to be significant.

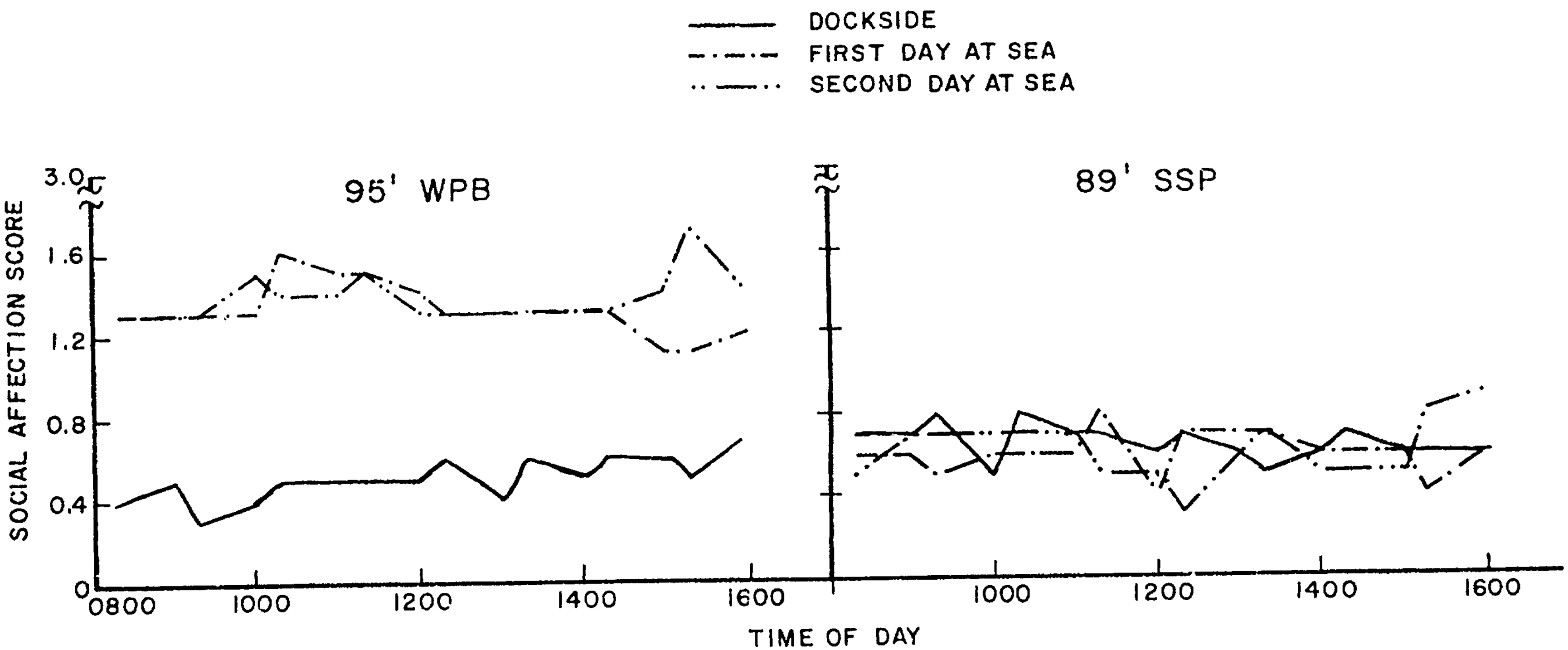


Figure 18. Social affection score means plotted as a function of vessel class. test day and time of day.

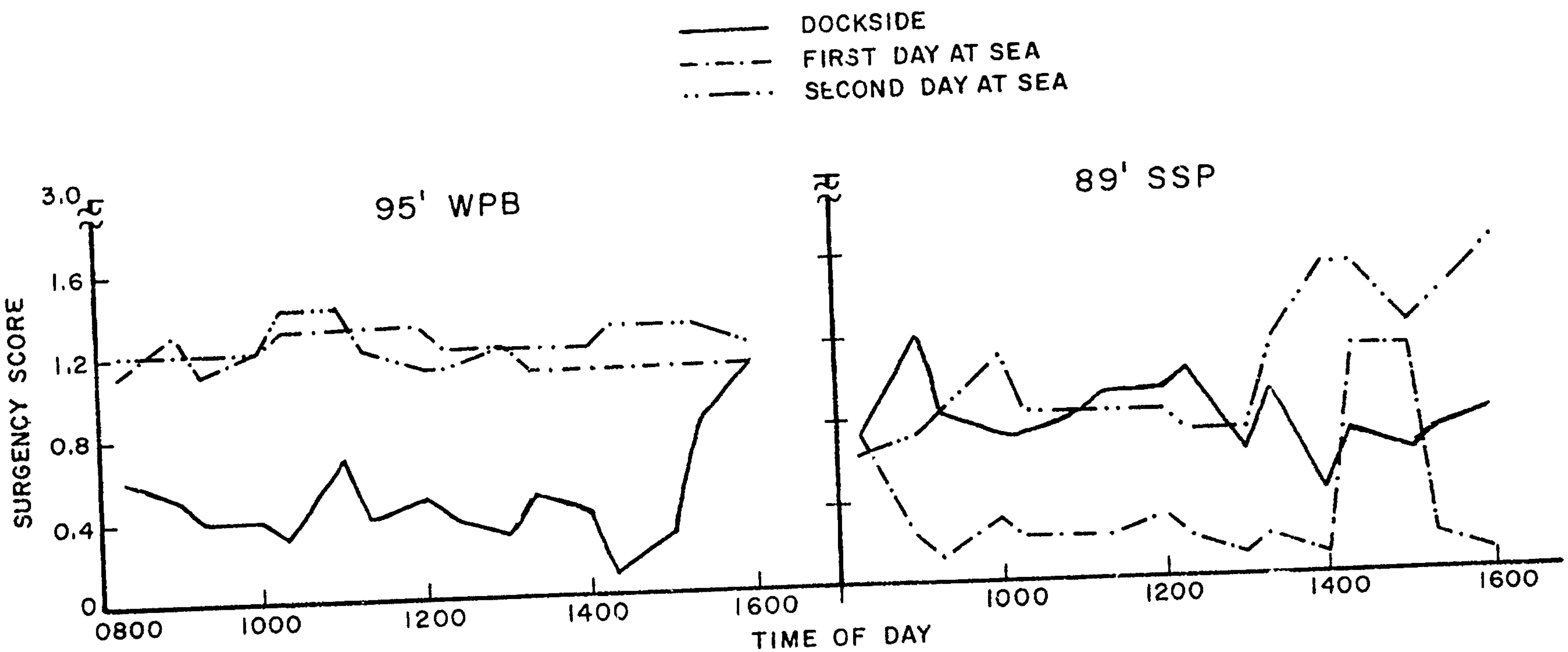


Figure 19. Surgency score means plotted as a function of vessel class, test day and time of day.

Reports of vigor increased by 6.0 percent of the score range from dockside to steaming periods aboard the WPB ($F(1,190) = 4.4$, $p < .05$) while a 14.2 percent decline was found aboard the SSP ($F(1,254) = 21.9$, $p < .001$).

During the steaming days, reports of vigor were slightly greater aboard the WPB than those obtained from the SSP ($p < .001$).

No significant changes in vigor were reported between the first and second days at sea across vessels. A small deline in reports of vigor was found aboard the vessels at sea as the day progressed ($p < .01$).

No significant interaction effects were found in vigor reports at sea. See Figure 20.

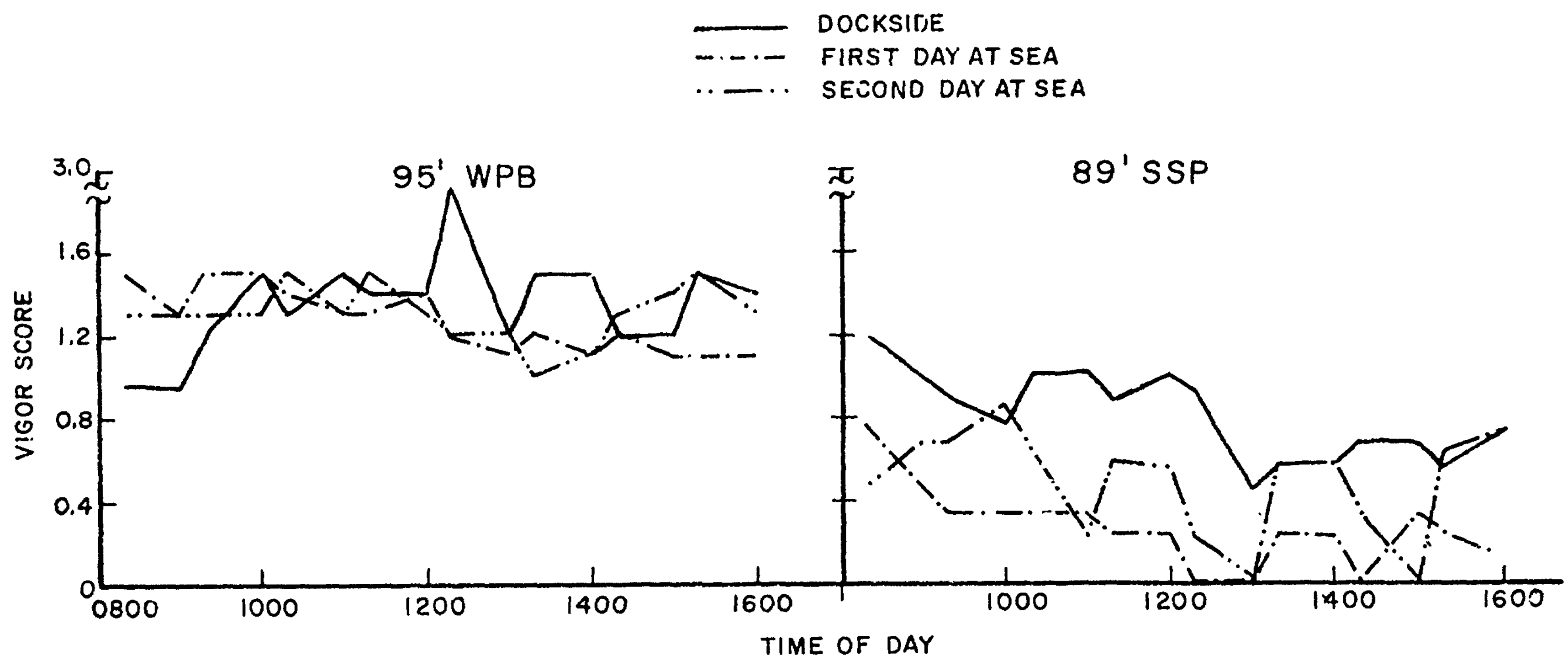


Figure 20. Vigor score means plotted as a function of vessel class, test day and time of day.

Performance Tests

The number of code substitutions performed decreased 16.2 percent from dockside to steaming periods aboard the WPB ($F(1,118) = 23.2$, $p < .001$) while no significant changes were found aboard the SSP ($F(1,126) = 0.1$, $p > .05$).

At sea, no differences were found between vessels in the number of substitutions performed over the two day period. The number of substitutions attempted increased 4.4 percent from the first to second day at sea across vessels ($p < .001$).

During the days at sea, code substitution performance varied significantly over the eight hour testing period. Performance increased in the morning, decreased midday during periods of greater vessel dynamics and subject motion sickness, and later increased as vessel dynamics and motion sickness subsided.

Analysis of interaction effects in code substitution data showed that the improvement in performance from the first to second day at sea was greatest aboard the WPB ($p < .05$). Furthermore, reductions in performance were greater aboard the WPB than the SSP during midday when seas were roughest ($p < .01$). In general, fewer code substitutions were attempted as the days at sea progressed, however, the trend was more significant during the first day at sea ($p < .001$). See Figure 21.

No significant changes were found in complex counting accuracy of the low tone from dockside to steaming periods aboard either the WPB ($F(1,98) = 2.3$, $p > .05$) or the SSP ($F(1,126) = 0.001$, $p > .05$).

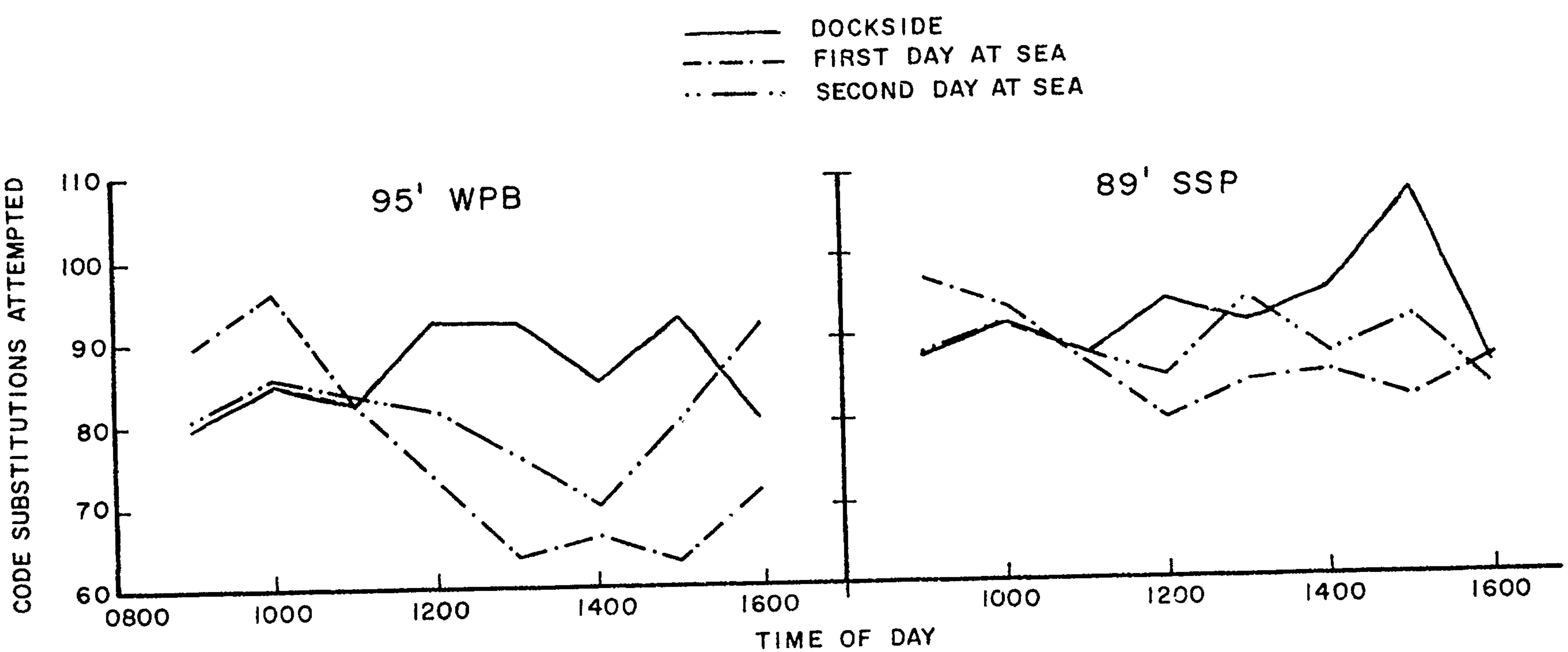


Figure 21. Mean number of code substitutions attempted as a function of vessel class, test day, and time of day.

At sea, no differences were found between the vessels over the two day period. No differences were found between the first and second days at sea across vessels either.

Variations were found in low tone monitoring accuracy over time of day at sea ($p < .01$) but no interaction effects were found to be significant. See Figure 22.

No significant differences were found in subject bandwidth limits between vessels over the two days at sea, or between the first and second steaming day across vessels.

Critical tracking performance aboard the vessels at sea did vary throughout the day ($p < .05$); particularly aboard the WPB. However, no signficant interaction effects were found. See Figure 23.

The number of navigation plotting problems completed aboard the WPB decreased from dockside to steaming periods by 27.0 percent ($F(1,118) = 47.2$, $p < .001$). Analysis of data from the SSP showed a 6.4 percent reduction in problems completed at sea ($F(1,126) = 6.4$, $p < .05$).

At sea, a greater number of navigation plotting problems were completed aboard the SSP than that aboard the WPB ($p < .05$). Performance increased 4.8 percent across vessels from the first to second day at sea ($p < .05$). The reduction in performance found during the midday periods at sea were also significant ($p < .001$).

All interaction effects in the navigation plotting completion scores were significant. Performance increased

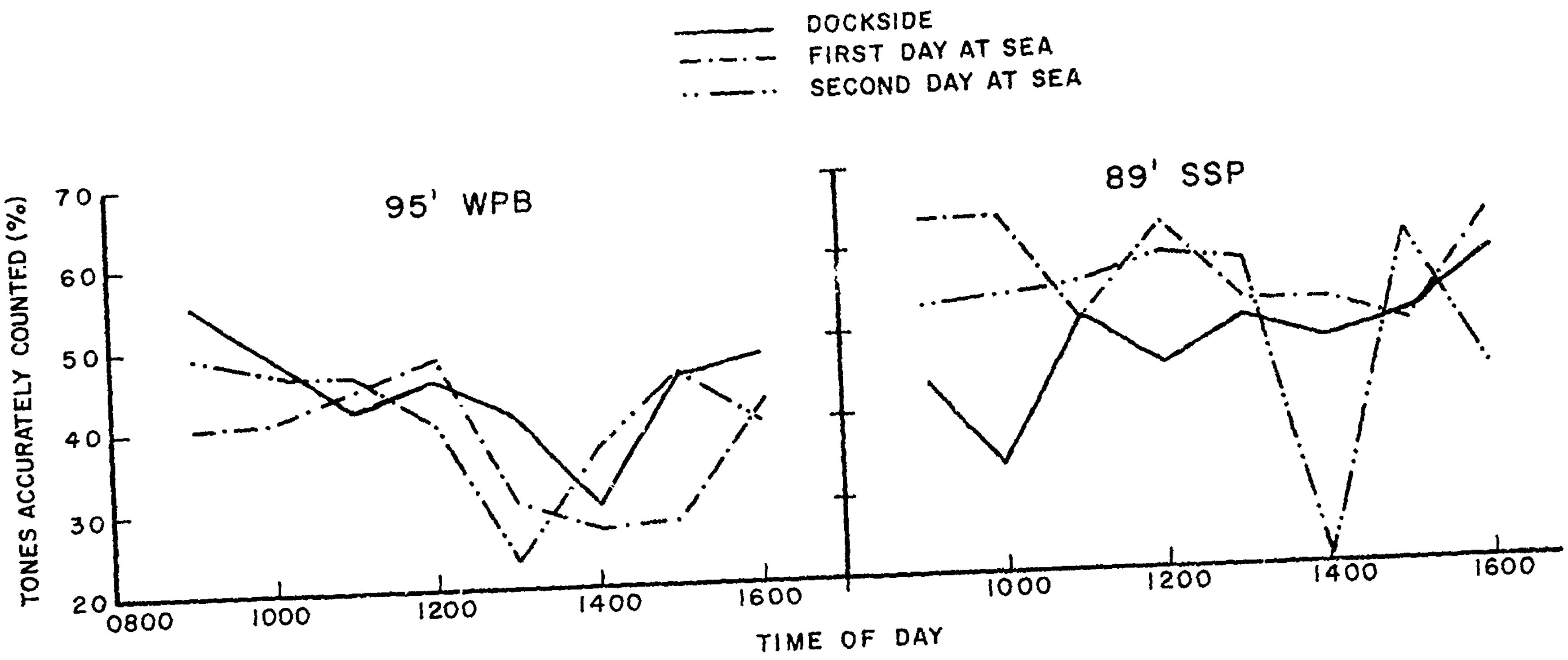


Figure 22. Mean accuracy of complex counting (low tone) as a function of vessel class, test day and time of day.

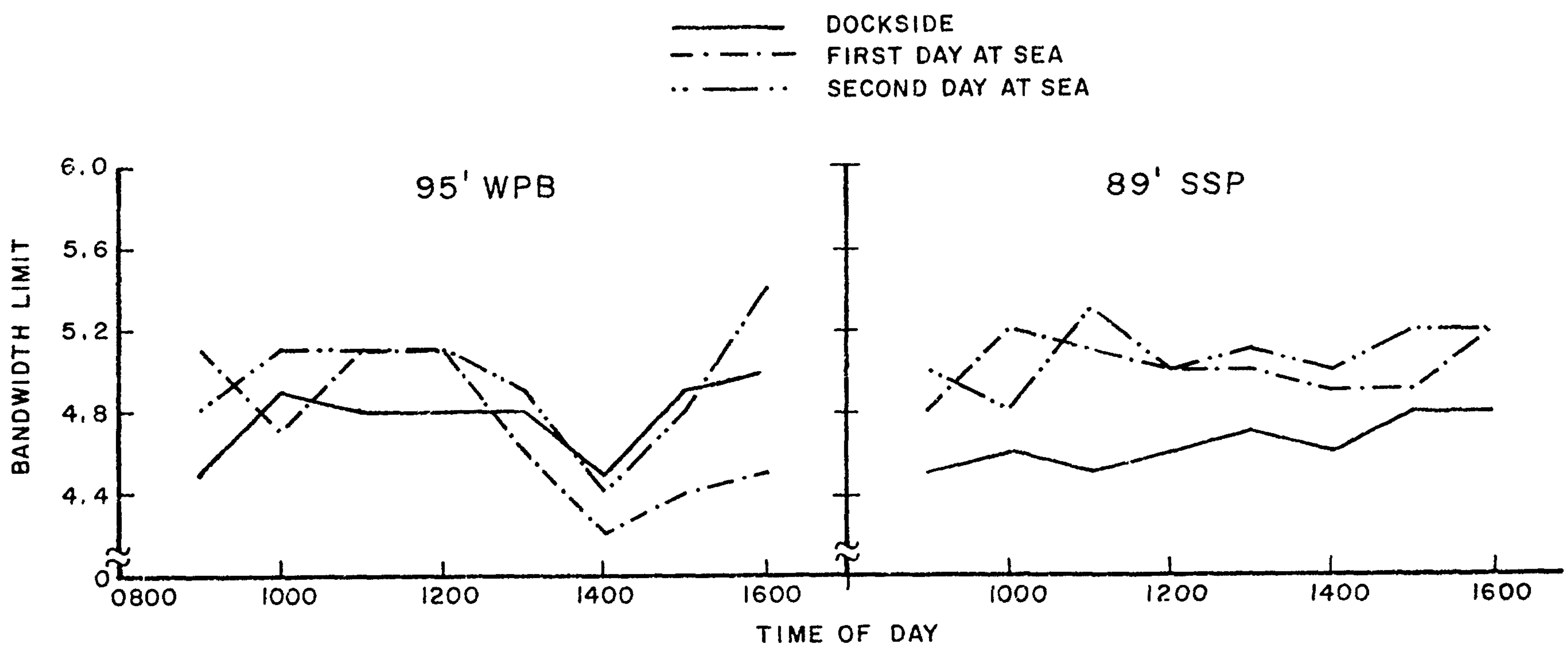


Figure 23. Mean critical tracking task performance plotted as a function of vessel class, test day and time of day.

from the first to second steaming day at a greater rate aboard the WPB ($p < .05$). There was also greater variation in the number of navigation plotting problems completed aboard the WPB than that found aboard the SSP ($p < .001$). The degree of performance variation aboard the WPB was greatest during the first day at sea ($p < .001$). See Figure 24.

The number of correct navigation plotting problems completed decreased 17.1 percent from dockside to steaming periods aboard the WPB ($F(1,118) = 13.2$, $p < .01$). No changes were found aboard the SSP ($F(1,126) = 0.01$, $p > .05$).

No differences were found in the number of correct solutions between the vessels at sea. No significant change was found in navigation plotting solution accuracy from the first to second steaming day across vessels. Significant variations in the number of correct solutions provided were found during the days at sea ($p < .001$).

The significant ship by day interaction showed that the nonsignificant increase in the number of correct answers provided was greater aboard the WPB than that found aboard the SSP ($p < .05$). There was also more variati·· in the number of correct solutions provided during the first day at sea when compared to the second. No other interaction effects were found to be significant. See Figure 25.

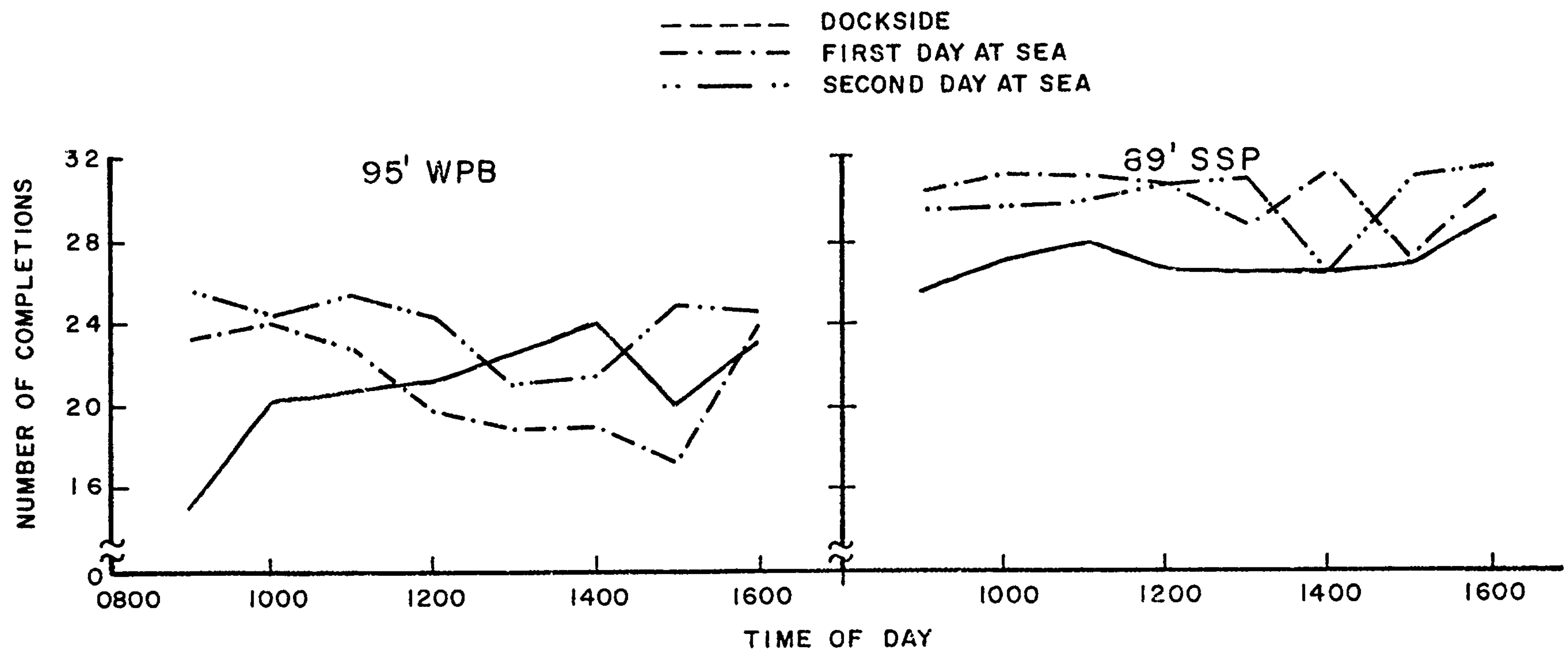


Figure 24. Mean number of navigation plotting problems completed as a function of vessel class, test day and time of day.

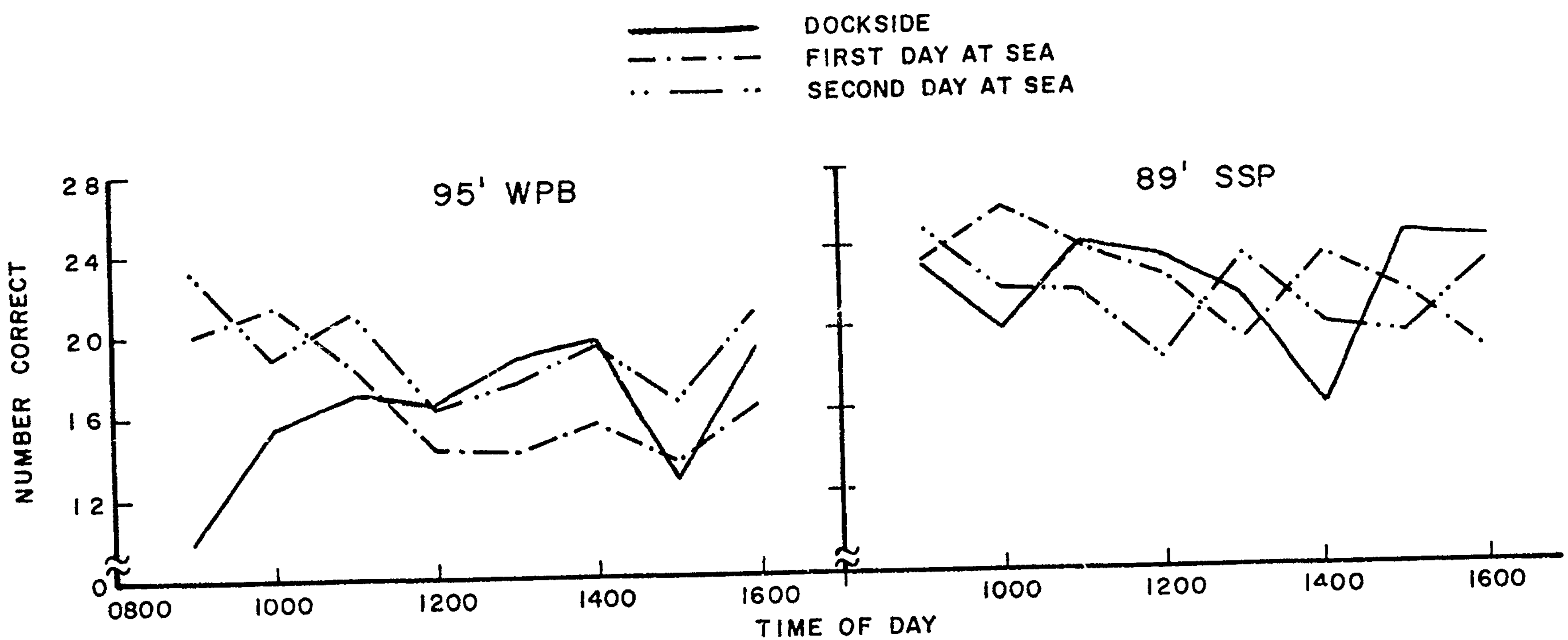


Figure 25. Mean number of correct navigation plotting problems completed as a function of vessel class, test day and time of day.

Spoke Test (control) completion times increased from dockside to steaming periods by 13.5 percent aboard the WPB ($F(1,118) = 36.2$, $p < .001$) and 8.8 percent aboard the SSP ($F(1,126) = 10.6$, $p < .01$).

At sea, completion times of the simple tapping component of the Spoke Test declined 4.3 percent from the first to second day at sea ($p < .05$); however, no differences were found between vessels. Completion times also varied throughout the day across vessels at sea ($p < .05$). Completion times were longer during the midday when vessel dynamics and motion sickness severity were greatest; particularly aboard the WPB ($p < .005$). No other interaction effects were found. See Figure 26.

Spoke Test (experimental) completion times did not change significantly from dockside to steaming periods aboard either the WPB ($F(1,118) = 1.8$, $p < .05$) or the SSP ($F(1,126) = 0.5$, $p < .05$).

At sea, no differences were found in the completion times of the combined visual search and tapping component of the Spoke Test between vessels over the two day steaming period. A 4.2 percent improvement in task performance was found from the first to second day at sea across vessels ($p < .001$).

No significant interaction effects were found in Spoke Test (experimental) completion time data at sea. See Figure 27.

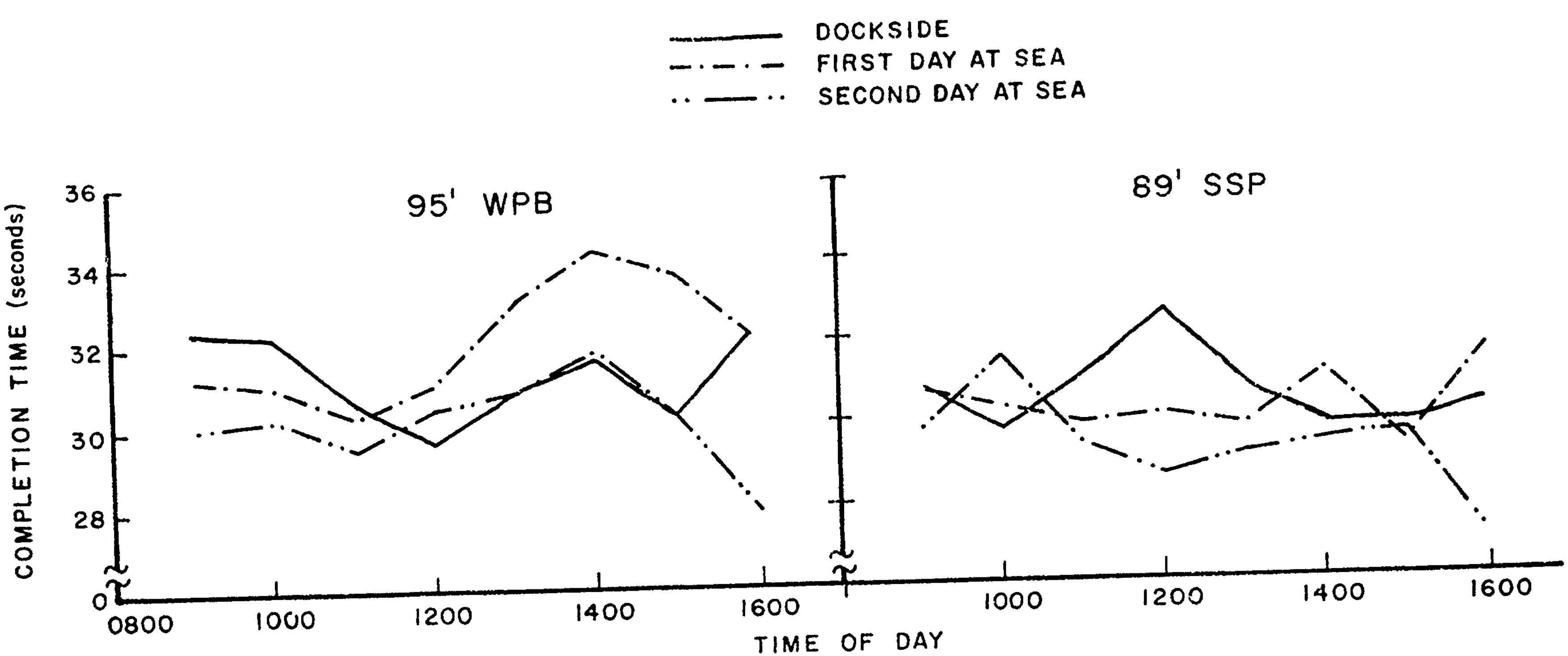


Figure 26. Mean Spoke Test (control, completion times as a function of vessel class, test day and time of day.

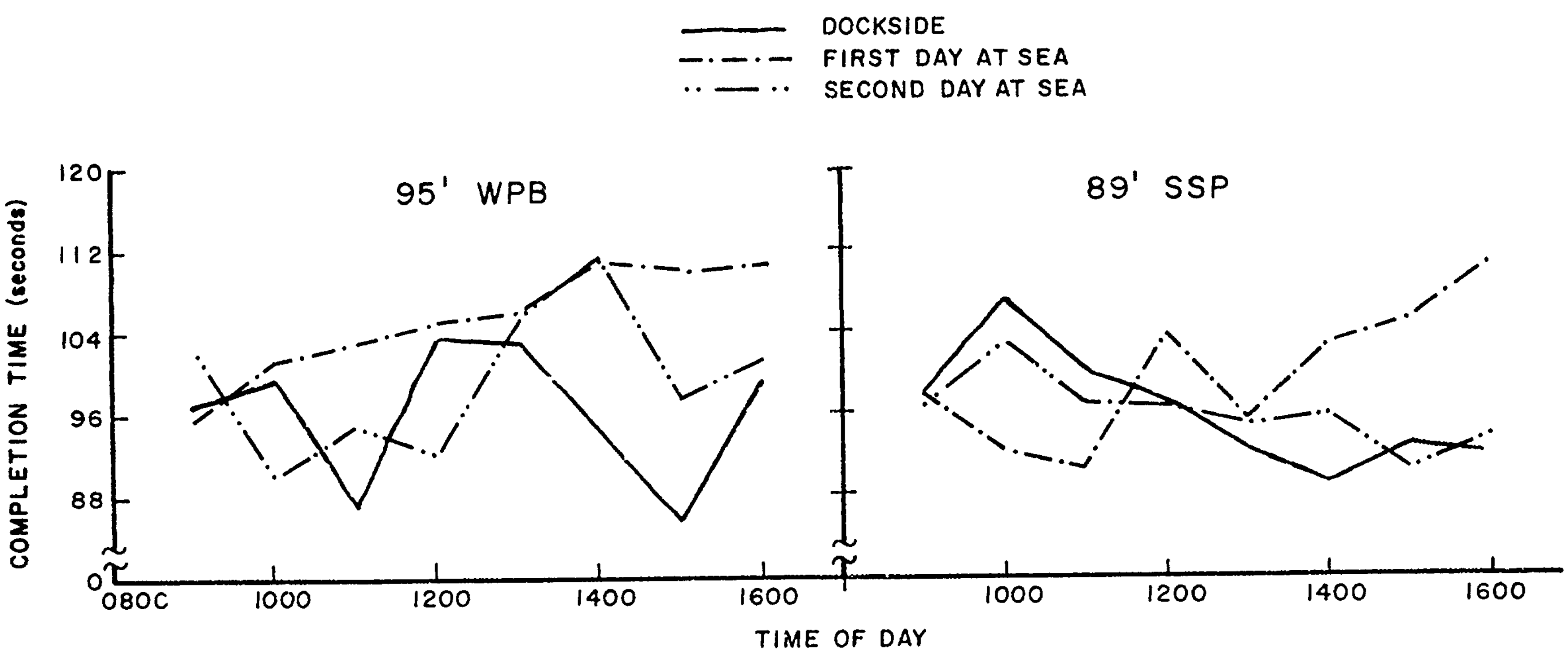


Figure 27. Mean Spoke Test (experimental) completion times as a function of vessel class, test day and time of day.

Spoke Test (difference) times, estimates of the visual search time component of the Spoke Test, showed no significant differences between dockside and steaming periods aboard either the WPB ($F(1,118) = 0.1$, $p > .05$) or the SSP ($F(1,126) = 0.01$, $p > .05$).

At sea, no differences were found between the vessels over the two day period. A 4.8 percent reduction in the time accrued to visual search was found from the first to second day at sea across vessels ($p < .05$).

Variations, or trends, found in difference times during the days spent at sea were, along with all interaction effects, found to be insignificant. See Figure 28.

Estimates of a twelve-second time interval did not change significantly from dockside to steaming periods aboard either the WPB ($F(1,95) = 1.4$, $p > .05$) or ther SSP ($F(1,103) = 0.1$, $p > .05$).

At sea, no differences were found in time estimates between vessels over the two day period. Time estimates did decline slightly from the first to second steaming days across vessels ($p < .05$).

Estimates made at sea did not show any significant time of day or interaction effects. See Figure 29.

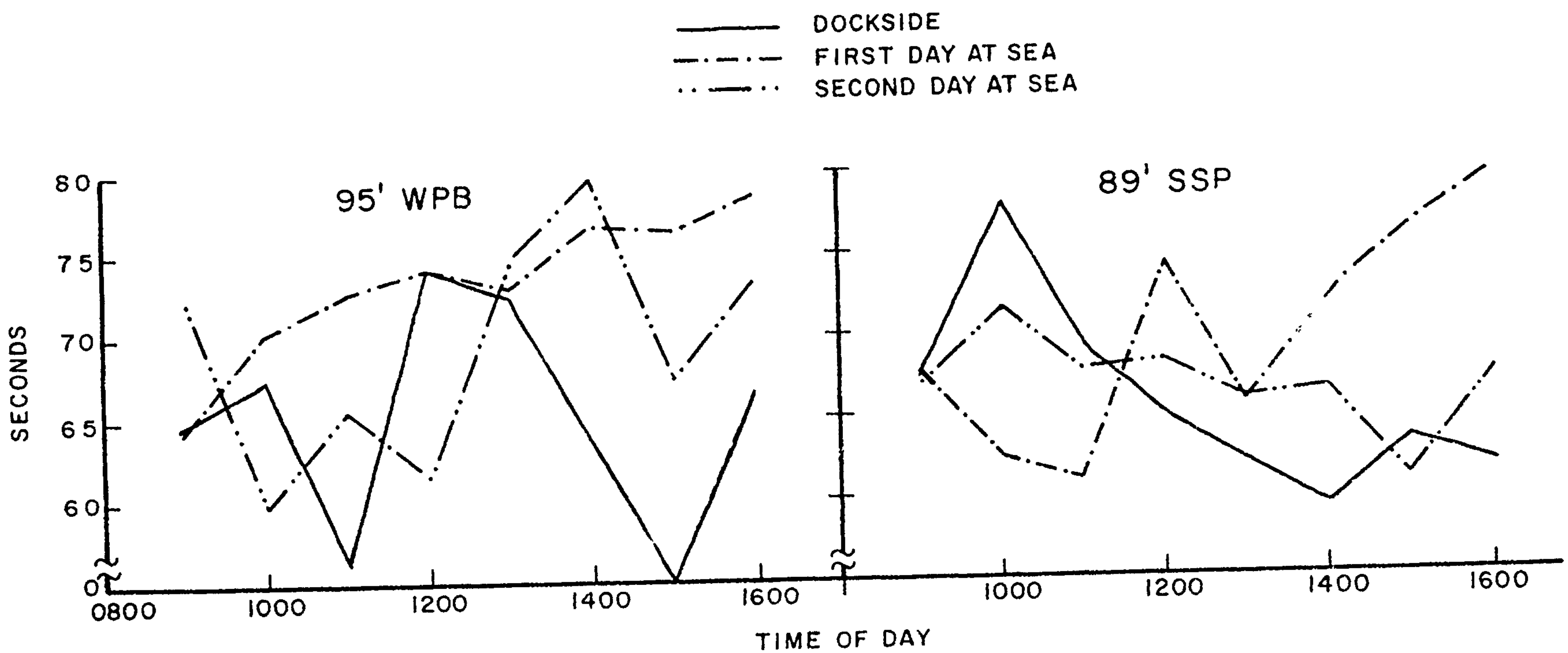


Figure 28. Mean Spoke Test (difference) times as a function of vessel class, test day and time of day.

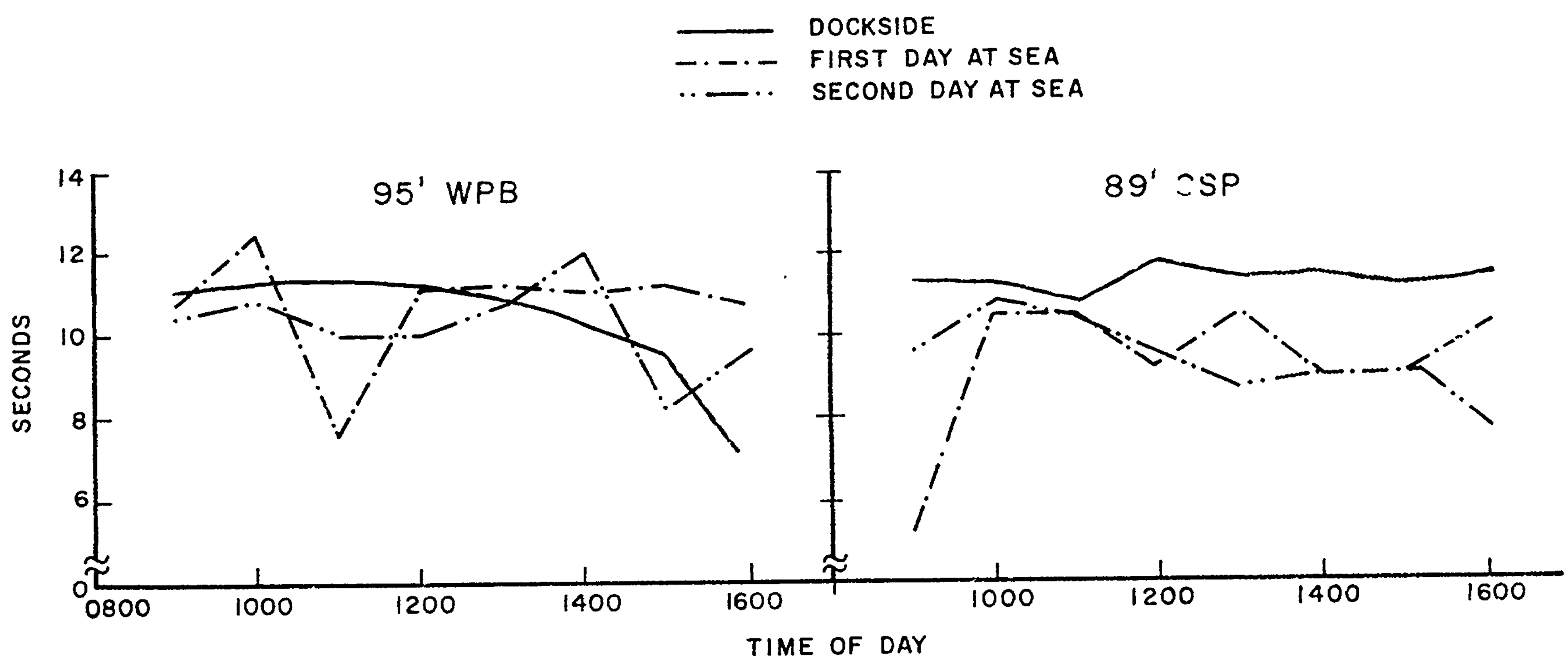


Figure 29. Mean estimates of a twelve second period plotted as a function of vessel class, test day and time of day.

Multivariate Analyses:

Correlations between individual daily means of each variable measured during the two steaming days were factor analyzed using a varimax rotation of principal components. Correlations used to derive the factor structure matrix provided in Table 3 are provided in appendix J.

Table 3 shows that nine factors were required to explain 90.9 percent of the total variance. The first factor shows that elevations in vessel vertical and lateral accelerations along with reductions in average frequencies of vertical, lateral and longitudinal motions were associated with increasingly severe reports of motion sickness sympotomatology. At the same time both positive and negative mood dimensions were elevated.

The second factor indicates improvements in task performance were associated with reported increases in subject concentration.

The third factor shows that reductions in various negative mood dimensions were correlated with reductions in heart rate, increased numbers of code substitution and navigation plotting problems completed, and increased completion times required for the Spoke Test (experimental).

The fourth factor indicates that as motion sickness severity and test compartment relative humidity increased, urine output declined, urine specific gravity increased and 17-OHCS excretion rates declined.

The remaining factors accounted for only a small portion of the variance; thus, they are not discussed.

TABLE 3

Varimax Rotated Factor Matrix

Measure	Factors 1	2	3	4	5	6	7	8	9	h^2
MSSS Score	.49	-	-	.66	-	-	-	-	-	.88
Urine Output	-	-	-	-.88	-	-	-	-	-	.92
Urine Sp. Gr.	-	-	-	.89	-	-	-	-	-	.89
17-OHCS	-	-	-	-.43	-	.48	-.31	.44	-	.84
Catecholamines	-	-	-	-	.44	-	.48	-	.38	.67
Heart Rate	-	-	.85	-	-	-	-	-	-.43	.79
Sweat Rate	-	-	-	-	-	-	-	.88	-	.82
Code Substitution	-	.58	-.31	-.38	-	.37	-	-	-	.90
Complex Counting	-	.30	-	-	-.58	.39	-	.31	-	.84
Critical Tracking	-	.69	-	-	-	.62	-	-	-	.97
Nav/Plot Attempts	-.44	.46	-.33	-	-.57	-	-	-	-	.92
Nav/Plot Correct	-.33	.57	-	-	-.56	-	-	-	-	.93
Spoke (control)	-	-	-	-	.81	-	-	-	-	.76
Spoke (experiment.)	-	-	-.95	-	-	-	-	-	-	.94
Spoke (difference)	-	-	-.95	-	-	-	-	-	-	.95
Time Estimation	-	-	-	-	-	.86	-	-	-	.81
Aggression	.44	-	.69	-	-	-	-	-	-	.94
Anxiety	.62	-	.61	-	-	-.35	-	-	-	.97
Concentration	.33	.43	.39	-	-	.54	-	-	-	.83
Egotism	.86	-	-	-	-	-	-	-	-.34	.96
Elation	.81	-	-	-	-	-	-	-	.30	.93
Fatigue	.31	-	.85	-	-	-	-	-	-	.96
Sadness	.75	-	-	-	-	-	-	-	-	.84
Skepticism	.52	-	.30	-	-	-	-	-	-.69	.88
Social Affect.	.68	-	-	-	-	-	-	-	.38	.69
Surgency	.68	-	-.43	-	-	-	-.43	-	-	.94
Vigor	.86	-	-	-	-	-	-	-	-	.92
Vert. rms g	.97	-	-	-	-	-	-	-	-	.99
Long. rms g	-.83	-	-	-	-	-	-.47	-	-	.97
Lat. rms g	.96	-	-	-	-	-	-	-	-	.99
Vert. Max. Amp.	.89	-	-	-	-	-	-	-	-	.98
Long. Max. Amp.	-.90	-	-	-	-	-	-.34	-	-	.99
Lat. Max. Amp.	.95	-	-	-	-	-	-	-	-	.99
Vert. Hz Max. Amp.	.96	-	-	-	-	-	-	-	-	.99
Long. Hz Max. Amp.	.88	-	-	-	-	-	-	-	-	.97
Lat. Hz Max. Amp.	.96	-	-	-	-	-	-	-	-	.99
Vert. Hz	-.88	-	-	-	-	-	-.40	-	-	.99
Long. Hz	-.92	-	-	-	-	-	-	-	-	.99
Lat. Hz	-.92	-	-	-	-	-	.30	-	-	.98
Temperature	-.84	-	-	-	-	-	.31	-	-	.96
Rel. Humidity	-	-	-	.46	-	-	.69	-	-	.95
Variance (%)	44.9	11.1	7.1	6.9	6.0	5.1	3.9	3.2	2.7	

Note: Scores less than .30 were arbitrarily omitted for clarity.

Multiple linear regression analysis was performed on half-hour group means of MSSS data collected aboard the WPB to examine the relationship between motion sickness severity and vessel motion record summary statistics.

Some measures of vessel motion were highly correlated. To deal with the multicolinearity problem all predictors which were correlated ($r > .60$) were grouped and a representative predictor from the group was selected for inclusion in the analysis. Selection of the representative predictor was based upon previous experimental findings; hence, vertical motion characteristics were given preference over lateral and longitudinal measures.

Results of the analysis are presented in figure 30. In reviewing the results it should be noted that vertical accelerations were highly correlated with both lateral and longitudinal accelerations aboard the WPB.

Physiological variables other than motion sickness, mood scores and performance task measures taken from subjects aboard both vessels at sea were regressed against MSSS scores, test compartment motion measures, and other independent variables such as temperature and time of day. Table 4 summaries the results of those analyses.

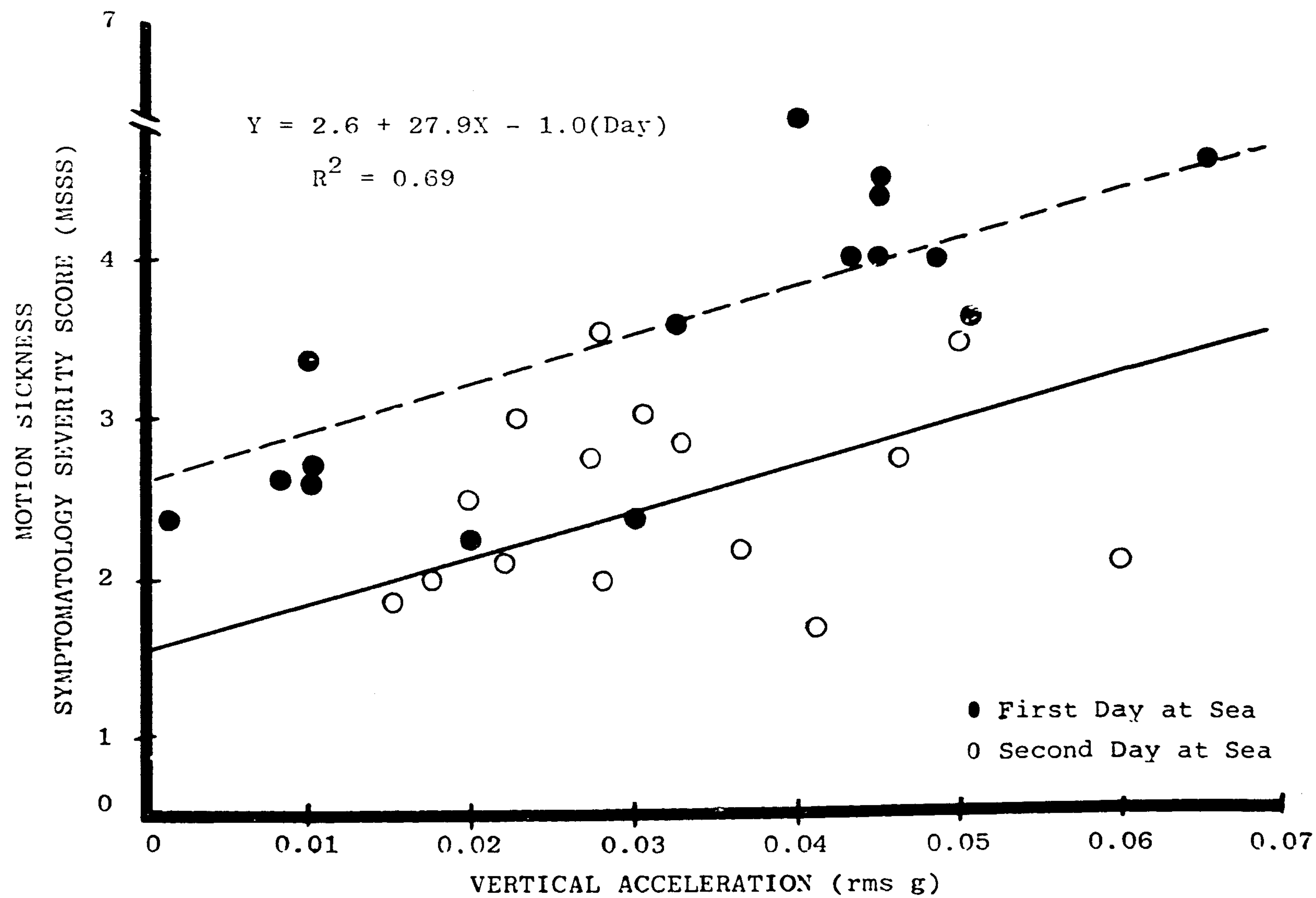


Figure 30. Motion sickness symptomatology severity as a function of vessel vertical acceleration and steaming day aboard the 95' WPB.

TABLE 4
Summary of Multiple Regressions of
Physiological, Mood and Performance Task Measures Against
Motion Sickness Scores, Vessel Motions and Other Measures Taken

WPB MEASURE =	Predictor Beta Coeficients				
	(MSSS)+	$(MSSS^2)$+	(Temp.)+	(Time of Day)	R^2
Urine Output	2.1	-1.8	-	-	.69
Urine Sp. Grav.	-1.5	1.0	-	-	.58
17-OHCS	-	-	-	-	-
Catecholamines	-	-	-	-	-
Heart Rate	-	-	.73	-	.26
Sweat Rate	-	-	-	-	-
Aggression	3.3	-3.1	-	-	.19
Anxiety	3.0	-2.6	-0.6	-0.7	.47
Concentration	-	-	-0.2	-0.2	.18
Egotism	-3.6	3.3	-	-	.27
Elation	-0.4	-	-	-	.14
Fatigue	1.7	-1.0	-	0.4	.50
Sadness	2.9	-2.3	-	-	.51
Skepticism	3.3	-2.9	-	-	.31
Social Affect.	1.5	-2.1	-	-	.44
Surgency	-3.6	3.0	0.3	-	.57
Vigor	2.3	-2.6	-	-	.16
Code Substitution	-0.6	-	-	-	.30
Complex Counting	-3.7	3.0	-	-	.62
Critical Tracking	-0.6	-	-	-	.34
Nav/Plot Attempts	-0.9	-	-	-	.85
Nav/Plot # Correct	-	-	-	-	-
Spoke (control)	-1.6	2.3	-	-	.68
Spoke (experimental)	0.7	-	-	-	.52
Spoke (difference)	-	-	-	-	-
Time Estimation	-0.5	-	-	-	.24

Note: dash lines indicate no significant coeficient was obtained.

DISCUSSION

In this experiment subjects were exposed to vessel motion environments aboard either a SWATH or comparably sized monohull for a period of thirty-two hours. Repeated sampling of physiological, mood and task performance measures during the first and last eight hours of exposure indicated that the subjects experienced some degree of adaptation to their respective test compartment environments at sea.

Operational restrictions placed upon the vessels during the experiment prevented the opportunity to examine responses to a sustained motion environment. However, within day variations in vessel acceleration histories were quite similar between data collection periods. This similarity allowed us to examine the effects of subject adaptation from a day to day basis.

Before discussing the magnitude and impact of subject adapation observed at sea it is necessary to point out the differential effects of each vessel's motion environment upon test subject physiological and psychological state and their performance on a range of psychomotor and cognitive tasks.

Comparing measures taken during the two eight hour data collection periods at sea with data collected in a similar manner at dockside revealed very few differences in subjects aboard the 89' SSP Semi-Submersible Platform (SWATH vessel). No differences were found in reports of motion sickness symptomatology severity (MSSS), urine output or specific gravity, excretion of 17-OHCS or catecholamines, and in either heart or sweat rates. With the exception of small decrements in navigation plotting task and Spoke Test (control) performance, no decrements were found in subject performance aboard the SSP at sea compared to dockside levels.

Subjects aboard the SSP did report small elevations in feelings of aggression, sadness and skepticism with concomitant declines in reports of egotism and vigor. The remaining six dimensions of mood remained unchanged from dockside levels.

On the other hand, subjects aboard the 95' WPB Patrol Boat exhibited antidiuresis, a decline in excretion of 17-OHCS and a mild increase in heart rate at sea. Subjects were clearly motion sick in the afternoons of both steaming days, however, the very calm conditions in the mornings and reduction in symptomatology severity during the second day at sea precluded any statistically significant differences in MSSS means between dockside and at sea periods.

Subjects aboard the WPB experienced small shifts in mood from dockside to steaming periods in all mood dimensions except aggression and anxiety. Reports of concentration declined as egotism, sadness surgency, elation, fatigue, social affection, skepticism and vigor increased in magnitude respectively.

Comparing performance task measures taken from the WPB at sea with those recorded at dockside showed moderate declines in the number of code substitutions and navigation plotting problems completed and their accuracy in the navigation task. Spoke Test (control) completion times were also increased at sea. No significant changes were found, however, in complex counting accuracy, Spoke Test (experimental) or Spoke Test (difference) times, and in time estimates of a twelve second period.

Two points must be made here. First, the SWATH hull design provided a more stable environment than that of the monohull in even relatively mild seas. This differential in test compartment stability was associated with a lack of motion sickness, physiological stress and significant task performance decrements. Second, the small elevations in certain dimensions of subject mood (e.g. aggression, sadness and skepticism) aboard the SSP indicate there was some cost to the subjects associated with the prolonged and repetitive sampling procedures. The testing paradigm itself was demanding and contributed to at least some shift in subject mood aboard both vessels as testing wore on.

The magnitude and breadth of changes observed in subjects aboard the WPB were less than those reported in a preceeding report (Wiker et al., 1980). The milder sea state experienced, the less severe and sustained periods of motion sickness and the opportunity for subjects to adapt to their respective motion environments probably mitigated the environmental effects upon the test subjects in this experiment.

Adaptation to the vessel motion environments aboard the WPB was most evident in the reduction of MSSS scores and antidiuresis from the first to second day at sea. Mean heart rates, which did not vary significantly in the previous study in which vessel motions and motion sickness were more severe, increased only very slightly from the first to second day at sea. Excretion of 17-OHCS, catecholamines and sweat remained constant between the days spent at sea.

The lack of change in catecholamine and sweat excretion rates between the days spent at sea was not surprizing. Neither catecholamine excretion or sweat samples taken from the same subjects in an earlier multi-vessel comparison at sea proved to be discriminating. The decline of 17-OHCS excretion rates from dockside to steaming periods aboard the WPB and the lack of significant changes in such rates between days spent at sea was unexpected. Previous laboratory and field studies have shown correlations between adrenal cortex activity and motion sickness onset and severity (Colehour and Graybiel, 1966; Eversmann et al., 1978; Wiker et al., 1980). Inconsistencies in experimental results with both catecholamines and glucocorticoid excretion rates in response to motion sickness and whole body acceleration exposures have been cited in the past. Graybiel et al. (1965) having exposed four aviators to ten days of coriolis stimulation in the Pensacola Slow Rotation Room, found catecholamine and 17-OHCS excretion elevations only during the eighth and tenth days of exposure. Additionally, exposure of six experienced WPB crewmen to two consecutive eight-hour days at sea, which resulted in prolonged and severe periods of motion sickness during both days, produced elevations in 17-OHCS excretion only during the last day at sea (Wiker and Pepper, 1978).

Perhaps the emotional component in adrenal cortical response to motion sickness is responsible for the aforementioned inconsistencies in experimental findings. Where experimental exposures are such that subjects may anticipate adaptation to the environment, and cessation of motion sickness, subject emotional stress may be less than that in experiments which offer little hope of adaptation during exposures.

It should be noted that the magnitude of 17-OHCS excretion rates at sea aboard the WPB were comparable to those found in the preceeding study; however, the dockside levels found in this study were somewhat greater. Subjects remarked that testing during the dockside period was more monotonous than when at sea, thus, the stress of boredom may have increased adrenal cortical activity during dockside testing.

With the exception of slight declines in reports of fatigue and elevations in surgency from the first to second day at sea, no changes were found in subject mood with subject adaptation to the vessel motion environment.

Mood scores indicated that subjects were generally stoic and that emotional state did not change with the introduction of motion sickness during the afternoon periods at sea. The elevations in subject mood from dockside to steaming periods aboard the WPB and the lack of any adaptive response between steaming days may reflect the subjects' dissatisfaction with their selection for exposure to the WPB motion environment. In any event, the significant correlations found between mood scores and motion sickness severity relect test subject population differences and not strictly motion sickness effects.

Task performance improved slightly from the first to second day at sea in code substitution, navigation plotting and the Spoke Tests. The remaining performance measures remained unchanged. Improvements in the aforementioned tasks were greatest in subjects aboard the WPB. Factor analysis results suggest that improvements in task performance were associated with a reduction in motion sickness severity, a reduction in vessel dynamics, increased reports of subject concentration and positive mood state.

Interpretation of the factor analysis results must be made with care. Individual daily means of measures were used to produce the correlation matrix analyzed. As such, vessel motion measures, motion sickness and mood scores were largely dichotomous between vessels; thus, relationships found might not only reflect differences between the experimental environments but inherent differences between subject populations as well.

Multiple regression analysis of group means of half-hour or hourly data was conducted to specifically address whether motion sickness, vessel motions or a combination of both were responsible for changes observed in physiological, mood and performance task data. The results which are summarized in Table 4 show that in the majority of data yielding a significant linear relationship with a predictor, responses were significantly related to changes in motion sickness symptomatology severity scores alone. Test compartment temperatures were associated with heart rate changes and some shifts in subject mood. Progression of the testing period was associated with declines in subject anxiety, concentration and accumulation of fatigue. No measure of vessel test compartment dynamics, unrelated to MSSS, was significantly associated with response variable changes. In should be noted, however, that of the twenty-six response variables examined, in only nine of the variables could half of the variance be explained.

Unfortunately the exposure to vessel motions aboard the WPB were not sufficiently sustained to eliminate motion sickness during the last day at sea. As a result, motion sickness remained sufficiently correlated with vertical, lateral rms g accelerations.

Analysis of motion sickness reports showed that only vertical and lateral rms g accelerations and adaptation between steaming days accounted for any significant changes in motion sickness symptomatology severity. Test compartment motion frequency, which had previously been found to be the most significant factor in the onset and severity of motion sickness (O'Hanlon and McCauley, 1974; McCauley et al., 1976; Wiker et al., 1980), was not a factor in this experiment. Examination of test compartment spectral density zero crossing frequencies showed that there was little change in these measures throughout the day. Vertical motion frequency aboard the WPB averaged 0.30 $\pm$ 0.5 Hz during the sixteen hours of data collection. Although the influence of test compartment frequency of motion may have contributed to the overall level of motion sickness severity found aboard the WPB, the lack of significant changes in frequency characteristics during data collection, due to vessel ressonance characteristics, eliminated any meaningful relationship in this experiment.

As shown in Figure 30 there was a decline in subject motion sickness response to WPB test compartment acceleration levels after twenty-four hours of exposure to the vessel motion environment. The lack of a sustained level of test compartment accelerations throughout the steaming period, plus the relatively mild and short periods of motion sickness experienced by the subjects, prevented a greater degree of adaptation to the WPB's motion environment.

The regression equation provided in figure 30 indicates that the motion sickness symptomatology severity response decline due to subject adaptation was linear and that elimination of motion sickness through subject adaption would have most likely required several days for the acceleration environment experienced. On the other hand, relatively small reductions in test compartment vertical/lateral rms g acceleration levels lead to significant reductions in motion sickness severity. It would thus appear that reliance upon crew adaptation or habituation to motion environments would be a far less effective measure in motion sickness prevention or reduction than that of improved vessel ride characteristics.

CONCLUSIONS

The Small Waterplane Area Twin Hull (SWATH) vessel provided a more stable platform than that found aboard a comparably sized monohull in the mild sea state experienced in this study. Vessel motions experienced aboard the patrol boat led to motion sickness in all subjects, artidiuresis, small shigts in mood and small to moderate decrements in performance tasks such as code substitution, navigation plotting, and psychomotor and cognitive components of the the Spoke Test. For the most part such changes were not found in subjects aboard the SWATH vessel.

Twenty-four hours of continued exposure to the patrol boat's motion environment produced moderate reductions in motion sickness and associated physiological responses. However, the physiological adaptation was accompanied by only small improvements in degraded performance tasks and essentially no change in the overall mood state of subjects.

Strong correlations between vertical and lateral accelerations and motion sickness onset and severity prevented a definitive analysis of the roles motion sickness and vessel dynamics play in crew performance degradation. Reductions in task decrements during the second day at sea, when vessel dynamics were equivalent to those of the previous day and motion sickness severity declined, indicates motion sickness, to some degree, was responsible to performance decrements found.

Motion sickness severity in this study was associated primarily with vessel vertical or lateral rms g acceleration characteristics. Increased acceleration levels led to linear increases in motion sickness severity. The lack of significant variation in vessel motion frequencies during this experiment did not permit an analysis of possible motion frequency effects. These results concur with previous laboratory and field experiments and argue that vessel acceleration responses to even mild sea states should be kept as low as possible to avoid motion sickness onset or to reduce its severity and associated effects.

The rate of physiological adaptation found in this study was slow. The data indicate that if the mild variations in vessel accelerations found within each day were continued, physiological adaptation to the environment would have required days. This finding shows that the benefits of crew adaptation to relatively mild vessel motion environments are not as great as the immediate and sustained benefits of inherently stable hull designs exemplified by the SWATH vessel studied.

In closing, the findings of this experiment show certain performance tasks are susceptible to motion sickness and possibly mechanical interference associated with the monohull's motion environment in mild seas. Further research is required to determine the relative impact of motion sickness and platform dynamics upon crew performance and psychophysiological state. Such research should be conducted aboard laboratory simulators which enable greater control over experimental variables and orthogonalization of vertical, lateral and longitudinal accelerations presented to subjects. Laboratory studies should, however, consider the resonance characteristics of today's and future vessels and should employ periodic field tests to validate their experimental findings.

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APPENDIX A

Test Subject Preselection Questionnaire

APPENDIX A

PRESELECTION QUESTIONNAIRE

INSTRUCTIONS

The enclosed questionnaire has been provided in order to obtain some essential information concerning certain physical characteristics you may possess. This information will be used to help us select a representative group of test subjects for participation in the previously discussed study.

Crewmen selected as tentative candidates for participation in the sea trials will be notified within one week. At that time a more detailed description of performance measures will be presented. Demonstrations and practice sessions will be given during the more detailed briefing as well.

Strict confidentiality will apply to all information acquired in the questionnaire and only those associated with the USCG Ship Motion Research Team will have access to the information provided.

Date: ____________

CCD14 SEA TRIALS HUMAN FACTORS
SELECTION QUESTIONNAIRE

Name: ______________________ Age: ______ Sex: ______

Rate/Rank: ______________________ Married: ______ Single: ______

Unit: ______________________ Height: ______ Wt: ______

1. Have you ever participated in an experiment before?

   YES _____ NO _____ When? ______________________

2. Number of months spent onboard your present ship: __________

3. Total shipboard experience excluding your present ship:

   Ship type __________ Time onboard in months __________

   __________ __________

   __________ __________

   __________ __________

4. Have you ever been seasick? YES _____ NO _____. If YES, would you describe the experience. Please describe weather conditions, length of voyage, type of vessel, whether you recovered while at sea, (and if you became sick again), and any other factors you consider pertinent.

5. From your experience at sea would you say that you:

   Always get sick _____ Frequently get sick _____ Sometimes _____

   Rarely _____ Never _____

6. Have you ever been motion sick under any conditions other than at sea?

   YES _____ NO _____ If so, under what conditions?

7. If you vomited while experiencing motion sickness, did you:

   Feel better and remain so? ______________________

   Feel better temporarily, then vomit again? ______________________

   Feel no better, but not vomit again? ______________________

   Feel no better and continued to vomit repeatedly? ______________________

8. In general, how susceptible to motion sickness are you?

   Extremely _____ Very _____ Moderately _____ Minimally _____ Not at all _____

Name: ______________________

9. In the past 8 weeks have you been nauseated FOR ANY REASON?

NO _____ YES _____. If YES, explain: ______________________

10. In the past when you were nauseated for any reason, did you:

Vomit easily _____ Vomit only with difficulty _____ Retch and finally vomit with great difficulty _____ Could never vomit when nauseated _____ Never nauseated in life _____.

11. Have you ever vomited in your sleep after heavy partying on the previous night? YES _____ NO _____

12. What do you think your chances of getting sick would be in an experiment where 50% of the subjects get sick?

I almost certainly would _____
I probably would _____
I probably would not _____
I almost certainly would not _____

13. Most people experience faintness (not as a result of motion) 2 or 3 times a year. During the past year you have felt faint:

More than this _____
The same as this _____
Less than this _____
Never faint _____

14. How well do you understand your motives and reasons for doing things?

Very well _____
Better than most _____
About average _____
Less than average _____
Not well at all _____

15. Have you ever had an ear illness or injury which was accompanied by dizziness and/or nausea?

16. Were you a controller of a vehicle when you were motion sick?

17. Would you volunteer for an experiment where you knew that:

85% of the people became seasick? YES _____ NO _____
50% of the people became seasick? YES _____ NO _____
25% of the people became seasick? YES _____ NO _____
0% of the people became seasick? YES _____ NO _____

Name: ______________________

18. What was the highest level of education you have attained?

Eighth grade ________
High School ________
Two years in college ________
Four years in college ________
Graduate school ________

19. Most people experience slight dizziness (not as a result of motion) 3 to 5 times a year. The past year you have been dizzy:

More than this ________
The same as ________
Less than ________
Never dizzy ________

20. When you become motion sick what type of remedy do you use? (Medical or otherwise)

21. How concerned are you with your performance on:

School exams:	Very great _____	Great _____	Moderate _____	Little _____
Shipboard Performance:	_____	_____	_____	_____
Sporting Activities:	_____	_____	_____	_____

22. Do you normally expect to perform better _____, same as _____, or worse than _____ the average person?

23. Do you smoke daily _____, infrequently _____, or never _____?

24. Do you drink alcohol daily _____, heavily at infrequent times _____, lightly at infrequent times _____, rarely _____, never _____.

25. Do you frequently take medications or drugs?

NO _____ YES _____ (If YES, do not specify at this time)

26. Have you been ill in the past year? NO _____ YES _____. If YES, specify: severity, time course and locality (on body).

27. I am _____ am not _____ in my usual state of fitness.

APPENDIX B

Test Subject Consent Form

CGD14 SEA TRIALS HUMAN FACTORS
TEST SUBJECT CONSENT FORM

I, ________________________________ having attained my 18th birthday, and otherwise having full capacity to consent, do hereby volunteer to participate in an investigation entitled, "CGD14 SEA TRIALS HUMAN FACTORS ANALYSIS", under the direction of LTjg Steven F. Wiker USCGR.

The implications of my voluntary participation; the nature, duration, and purpose; the methods and means by which it is to be conducted; and the inconveniences and hazards to be expected have been thoroughly explained to me by LTjg Wiker, and are set forth in full on the reverse side of this Agreement, which I have initialed. I have been given an opportunity to ask questions concerning this investigation study, and any such questions have been answered to my full and complete satisfaction.

I understand that I may at any time during the course of this investigation study revoke my consent and withdraw from the study without prejudice, however, I may be required to undergo certain further examinations if, in the opinion of LTjg Wiker, such examinations are necessary for my health or well being.

________________________________ __________
Signature Date

I was present during the explanation referred to above, as well as the Volunteer's opportunity for questions, and hereby witness his signature.

________________________________ __________
Signature of Witness Date

I understand that I will be performing an array of cognitive and perceptual-psychomotor tasks while at dockside and at sea for a period of one week in mid April. ________

During this study I will be giving urine samples for analysis of stress hormones and specific gravities. ________

I understand that I will have surface electrodes attached to my chest during the study for monitoring my electrocardiogram (EKG). ________

I realize that there is a possibility that I may become seasick during the days in which we are steaming at sea. ________

I am aware that my diet and liberty hours will be strictly controlled and that during dockside and at sea trials my liberty will be curtailed. ________

I am aware that the purpose of this study is to gather important data on the effects of vessel motion, in different sea states, upon crew performance and well being. ________

APPENDIX C

Postexperimental Debriefing Questionnaire

APPENDIX C

POSTEXPERIMENTAL DEBRIEFING QUESTIONNAIRE

Name:________________________

Subject No.______ Date:____________________

1. Were you assigned or did you volunteer to serve in this experiment?

   Assigned_____Volunteered_____Why?____________________________________

   ____

2. Which ship motions (roll, pitch, or heave) affected your task performance most and least?

   Most________________________ Least________________________

4. Were you sick at any time during the experiment?

   No_____Yes_____If yes, were the experimenters aware that you were sick every time you got sick? Yes_____No_____

5. Did you report each sickness or note it in your log sheets? Yes_____No_____

6. What was the most meaningful task?________________________________

7. What was the least meaningful task?_______________________________

8. What was the most difficult task?_________________________________

9. What was the least difficult task?________________________________

10. What task did you like the best?__________________________________

11. What task did you like least?____________________________________

12. If given the chance, would you serve again in this experiment? No_____Yes_____

    Why?____

    Why not?____

13. What would you do to improve the experiment?_______________________

    ____

14. What physiological sampling technique was most bothersome?__________

    ____

15. What physiological sampling technique was least bothersome?_________

    ____

Name:____

16. How would you improve upon the physiological sampling techniques?

17. Which adjectives on the check list were most difficult to make decisions about? (Place in order of difficulty)

    1 ________________ 2 ________________ 3 ________________ 4 ________________

18. Which adjectives on the check list were least difficult to make decisions about? (Place in order of ease)

    1 ________________ 2 ________________ 3 ________________ 4 ________________

19. How would you improve upon the check list?

20. On which vessel do you think you performed best? (Rank order)

    1 ________________ 2 ________________ 3 ________________

21. On which vessel did you feel best? (Rank order)

    1 ________________ 2 ________________ 3 ________________

APPENDIX D

Mood and Motion Sickness Symptomatology Questionnaire

APPENDIX D

MOOD AND MOTION SICKNESS SYMPTOMATOLOGY QUESTIONNAIRE

DATE________________________ SUBJECT________________________

WATCH________________________

MOOD AND MOTION QUESTIONNAIRE

Mood Questionnaire

1. angry — Definitely_____ Slightly_____ Undecided_____ Definitely NOT_____ Remarks____________

2. clutched up — Definitely_____ Slightly_____ Undecided_____ Definitely NOT_____ Remarks____________

3. carefree — Definitely_____ Slightly_____ Undecided_____ Definitely NOT_____ Remarks____________

4. elated — Definitely_____ Slightly_____ Undecided_____ Definitely NOT_____ Remarks____________

5. concentrating — Definitely_____ Slightly_____ Undecided_____ Definitely NOT_____ Remarks____________

6. drowsy — Definitely_____ Slightly_____ Undecided_____ Definitely NOT_____ Remarks____________

7. affectionate — Definitely_____ Slightly_____ Undecided_____ Definitely NOT_____ Remarks____________

8. regretful — Definitely_____ Slightly_____ Undecided_____ Definitely NOT_____ Remarks____________

9. dubious — Definitely_____ Slightly_____ Undecided_____ Definitely NOT_____ Remarks____________

10. boastful — Definitely_____ Slightly_____ Undecided_____ Definitely NOT_____ Remarks____________

11. active — Definitely_____ Slightly_____ Undecided_____ Definitely NOT_____ Remarks____________

12. defiant — Definitely_____ Slightly_____ Undecided_____ Definitely NOT_____ Remarks____________

MOOD AND MOTION QUESTIONNAIRE

13. fearful — Definitely____ Slightly____ Undecided____
Definitely NOT____ Remarks______________________

14. playful — Definitely____ Slightly____ Undecided____
Definitely NOT____ Remarks______________________

15. overjoyed — Definitely____ Slightly____ Undecided____
Definitely NOT____ Remarks______________________

16. engaged in thought — Definitely____ Slightly____ Undecided____
Definitely NOT____ Remarks______________________

17. sluggish — Definitely____ Slightly____ Undecided____
Definitely NOT____ Remarks______________________

18. kindly — Definitely____ Slightly____ Undecided____
Definitely NOT____ Remarks______________________

19. sad — Definitely____ Slightly____ Undecided____
Definitely NOT____ Remarks______________________

20. skeptical — Definitely____ Slightly____ Undecided____
Definitely NOT____ Remarks______________________

21. egotistic — Definitely____ Slightly____ Undecided____
Definitely NOT____ Remarks______________________

22. energetic — Definitely____ Slightly____ Undecided____
Definitely NOT____ Remarks______________________

23. rebellious — Definitely____ Slightly____ Undecided____
Definitely NOT____ Remarks______________________

24. jittery — Definitely____ Slightly____ Undecided____
Definitely NOT____ Remarks______________________

25. witty — Definitely____ Slightly____ Undecided____
Definitely NOT____ Remarks______________________

26. pleased — Definitely____ Slightly____ Undecided____
Definitely NOT____ Remarks______________________

27. intent — Definitely____ Slightly____ Undecided____
Definitely NOT____ Remarks______________________

MOOD AND MOTION QUESTIONNAIRE

28. tired — Definitely_____ Slightly_____ Undecided_____ Definitely NOT_____ Remarks______________________

29. warmhearted — Definitely_____ Slightly_____ Undecided_____ Definitely NOT_____ Remarks______________________

30. sorry — Definitely_____ Slightly_____ Undecided_____ Definitely NOT_____ Remarks______________________

31. suspicious — Definitely_____ Slightly_____ Undecided_____ Definitely NOT_____ Remarks______________________

32. self-centered — Definitely_____ Slightly_____ Undecided_____ Definitely NOT_____ Remarks______________________

33. vigorous — Definitely_____ Slightly_____ Undecided_____ Definitely NOT_____ Remarks______________________

Motion Questionnaire

1. general discomfort — None_____ Slight_____ Moderate_____ Severe_____ Remarks______________________

2. fatigue — None_____ Slight_____ Moderate_____ Severe_____ Remarks______________________

3. boredom — None_____ Slight_____ Moderate_____ Severe_____ Remarks______________________

4. mental depression — None_____ Slight_____ Moderate_____ Severe_____ Remarks______________________

5. drowsiness — None_____ Slight_____ Moderate_____ Severe_____ Remarks______________________

6. headache — None_____ Slight_____ Moderate_____ Severe_____ Remarks______________________

7. "fullness of the head" — None_____ Slight_____ Moderate_____ Severe_____ Remarks______________________

8. blurred vision — None_____ Slight_____ Moderate_____ Severe_____ Remarks______________________

MOOD AND MOTION QUESTIONNAIRE

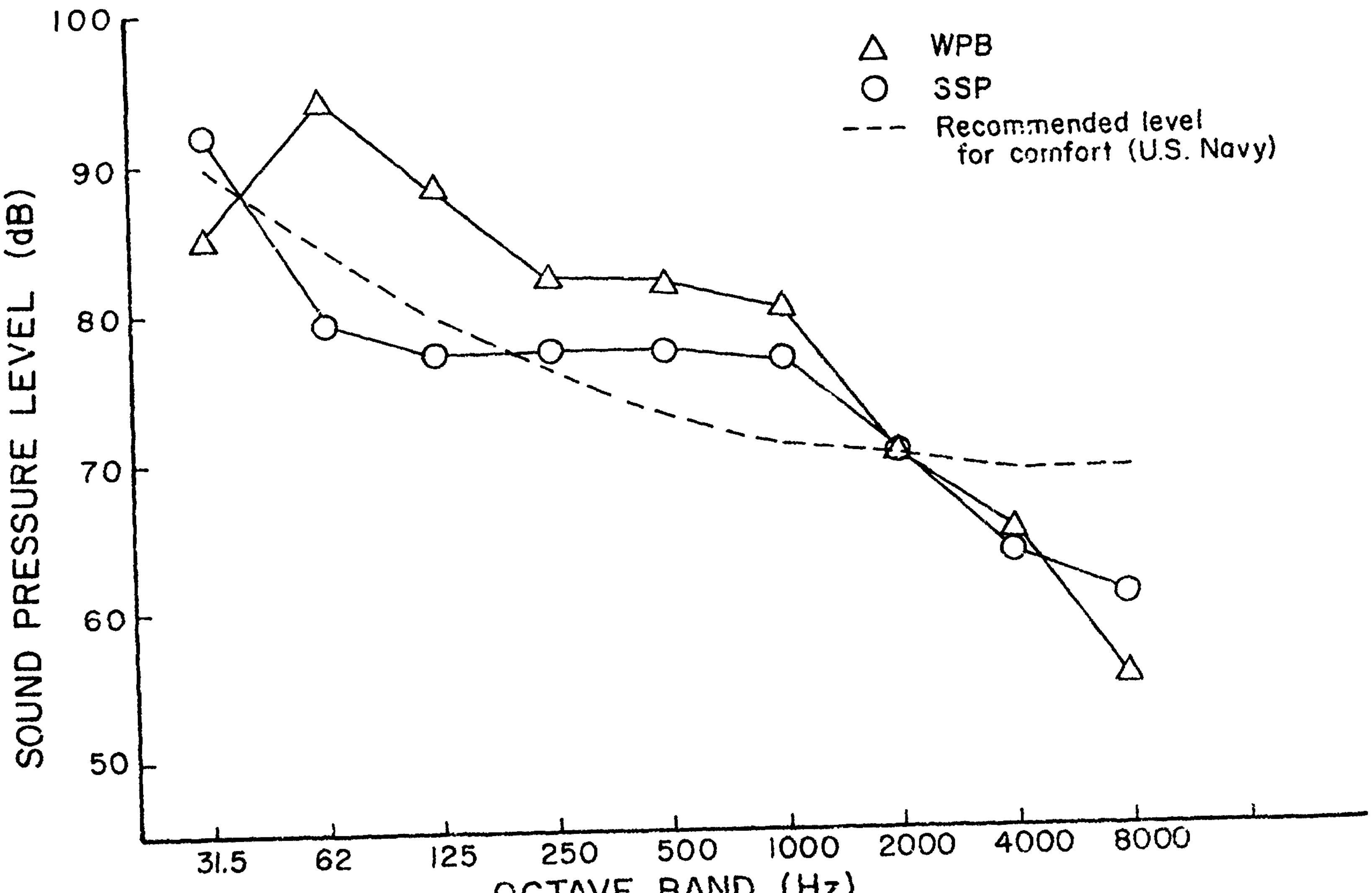
9.	a. dizziness with eyes open	None____ Slight____ Moderate____ Severe____ Remarks____
	b. dizziness with eyes closed	None____ Slight____ Moderate____ Severe____ Remarks____
10.	loss of direction	None____ Slight____ Moderate____ Severe____ Remarks____
11.	a. salivation increased	None____ Slight____ Moderate____ Severe____ Remarks____
	b. salivation decreased	None____ Slight____ Moderate____ Severe____ Remarks____
12.	sweating	None____ Slight____ Moderate____ Severe____ Remarks____
13.	faintness	None____ Slight____ Moderate____ Severe____ Remarks____
14.	aware of breathing	None____ Slight____ Moderate____ Severe____ Remarks____
15.	stomach upset	None____ Slight____ Moderate____ Severe____ Remarks____
16.	nausea	None____ Slight____ Moderate____ Severe____ Remarks____
17.	burping	None____ Slight____ Moderate____ Severe____ Remarks____
18.	loss of appetite	None____ Slight____ Moderate____ Severe____ Remarks____
19.	increased appetite	None____ Slight____ Moderate____ Severe____ Remarks____
20.	desire to move bowels	None____ Slight____ Moderate____ Severe____ Remarks____
21.	vomiting	None____ Slight____ Moderate____ Severe____ Remarks____

MOOD AND MOTION QUESTIONNAIRE

22.	confusion	None____ Slight____ Moderate____ Severe____ Remarks________________
23.	apathetic	None____ Slight____ Moderate____ Severe____ Remarks________________
24.	queasy	Yes____ No____ Remarks________________
25.	relaxed	Yes____ No____ Remarks________________
26.	clammy	Yes____ No____ Remarks________________
27.	yawning	Often____ Occasionally____ None____ Remarks________________
28.	smoking more than usual	Yes____ No____ Remarks________________
29.	physically tired	Very____ Somewhat____ No____ Remarks________________
30.	mentally tired	Very____ Somewhat____ No____ Remarks________________
31.	crave certain foods	Yes____ No____ Type________________
32.	claustrophobic	Yes____ No____ Remarks________________
33.	bothered by personal habits of partner	Yes____ No____ Remarks________________
34.	irritable	Very____ Somewhat____ No____ Remarks________________

APPENDIX E

Sound Pressure Levels in Vessel Testing Compartments



SOUND PRESSURE LEVELS IN VESSEL TESTING COMPARTMENTS

APPENDIX F

Testing Compartment Temperature and Releative Humidity Plots

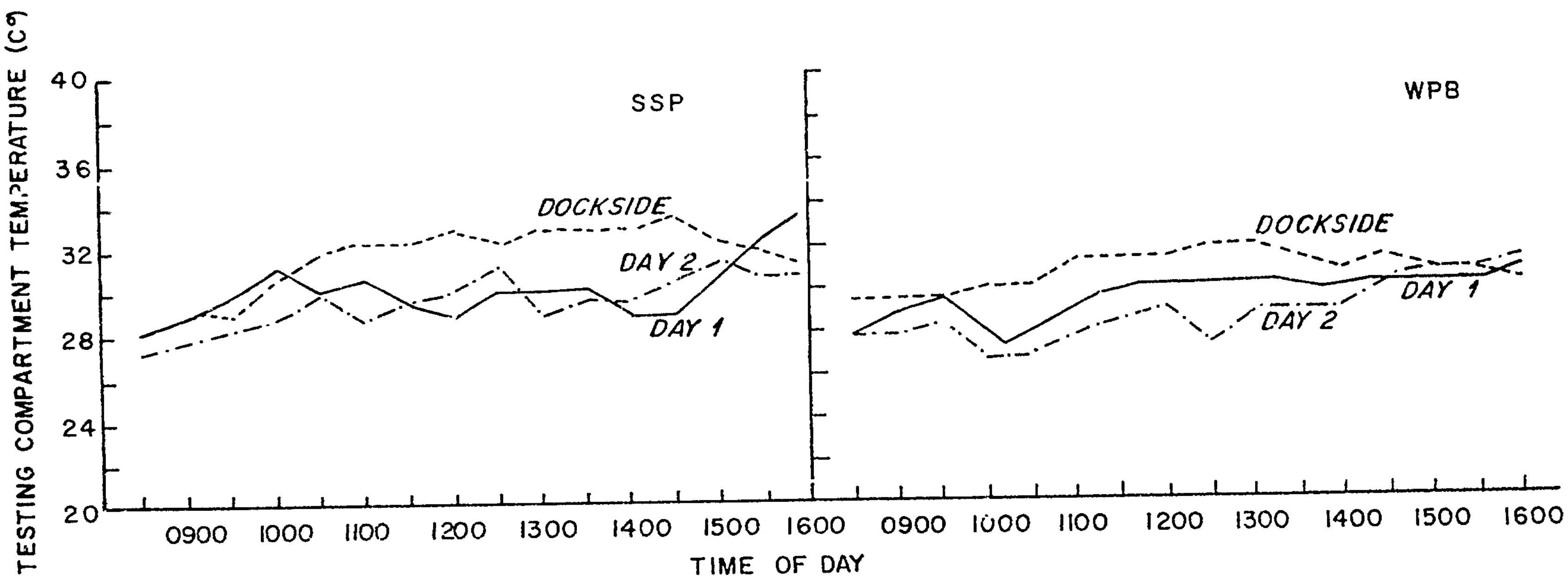


Figure F-1. Testing compartment temperature as a function of vessel class and testing day.

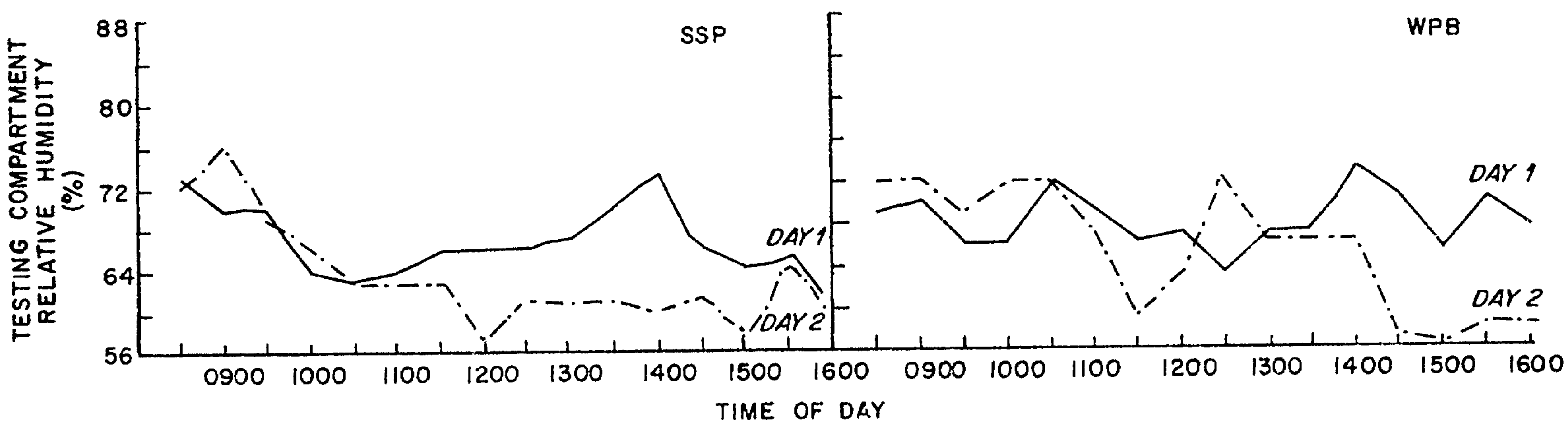


Figure F-2. Testing compartment relative humidity as a function of vessel class and steaming day.

APPENDIX G

Test Compartment Motions ANOVA Summary Table and Plots of Linear Accelerations Data

TABLE G-1

Summary of One-Way ANOVA Tests for

Daily Differences in Independent Measures Between Vessels

Independent Variable	First Steaming Day	Second Steaming Day
Temperature	-	-
Relative Humidity	-	-
Roll Hz	WPB	WPB
Pitch Hz	WPB	WPB
Heave Hz	WPB	WPB
Vertical Hz	WPB	WPB
Lateral Hz	WPB	WPB
Longitudinal Hz	WPB	WPB
Roll Amplitude	WPB	WPB
Pitch Amplitude	WPB	WPB
Heave rms g	WPB	WPB
Vertical rms g	WPB	WPB
Lateral rms g	WPB	WPB
Longitudinal rms g	-	-
Roll Hz at Max. Amp.	SSP	SSP
Pitch Hz at Max. Amp.	SSP	SSP
Heave Hz at Max. Amp.	N/A	N/A
Vertical Hz at Max. Amp.	WPB	WPB
Lateral Hz at Max. Amp.	WPB	WPB
Long. Hz at Max. Amp.	WPB	WPB
Roll Max. Spectral Amp.	WPB	WPB
Pitch Max. Spectral Amp.	WPB	WPB
Heave Max. Spectral Amp.	N/A	N/A
Vertical Max. Spectral Amp.	WPB	WPB
Lateral Max. Spectral Amp.	WPB	WPB
Long. Max. Spectral Amp.	SSP	SSP

Note: F-ratios exceeding the .05 alpha level are denoted by the symbol of the vessel possessing the highest daily mean. Dash lines indicate no significant differences. N/A indicates missing data.

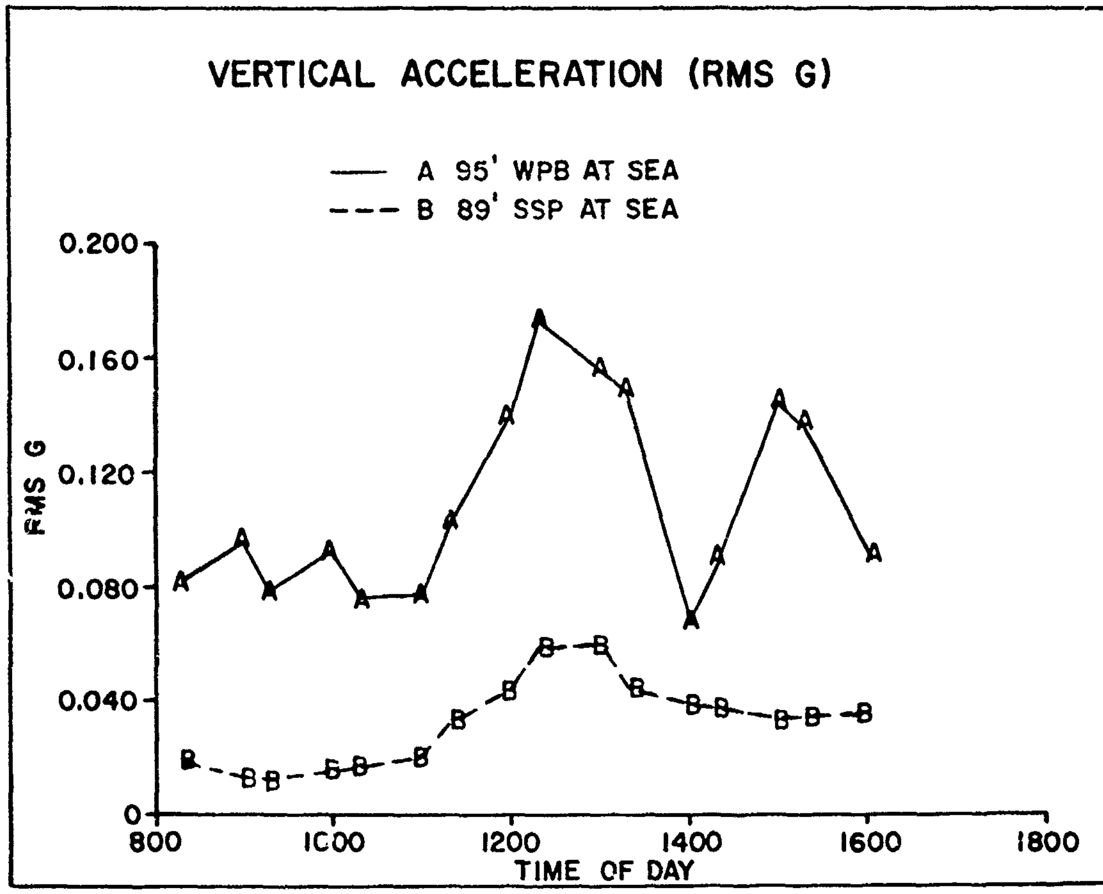


Figure G-2. Average single amplitude vertical accelerations aboard each vessel.

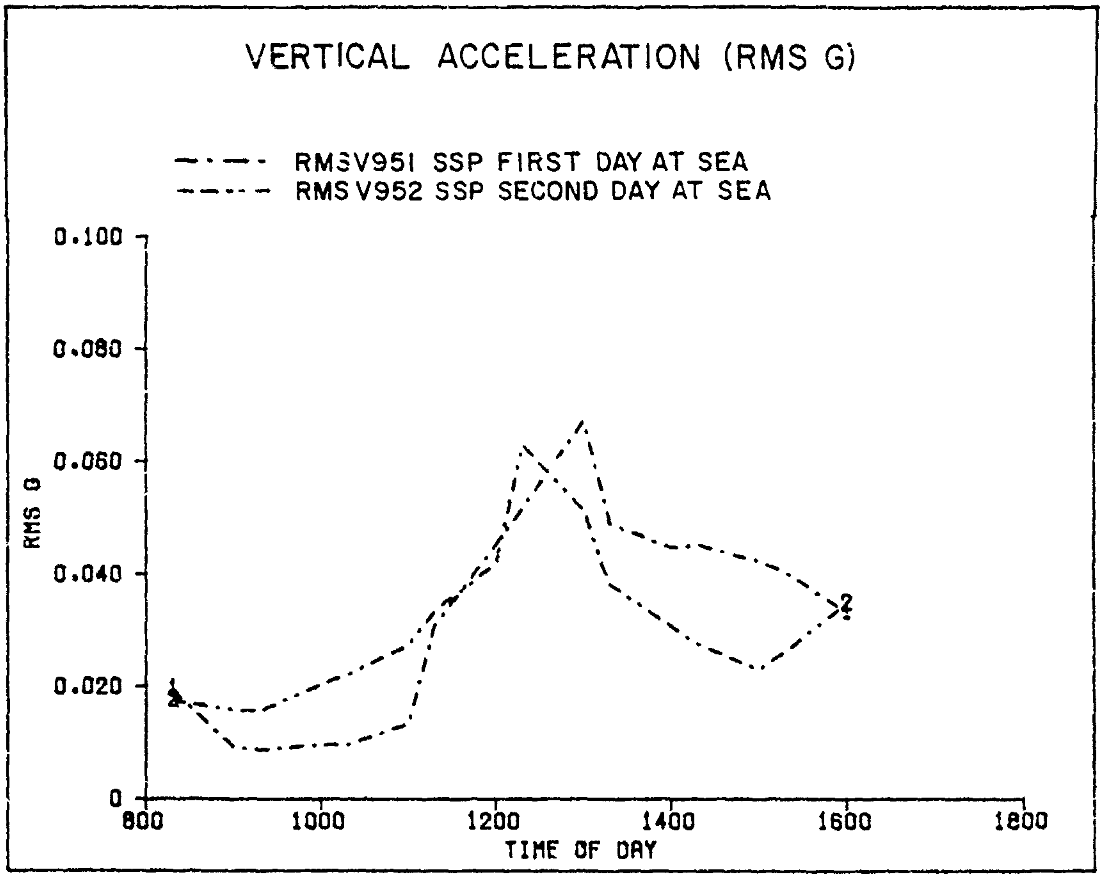


Figure G-3. Vertical single amplitude accelerations aboard the SSP.

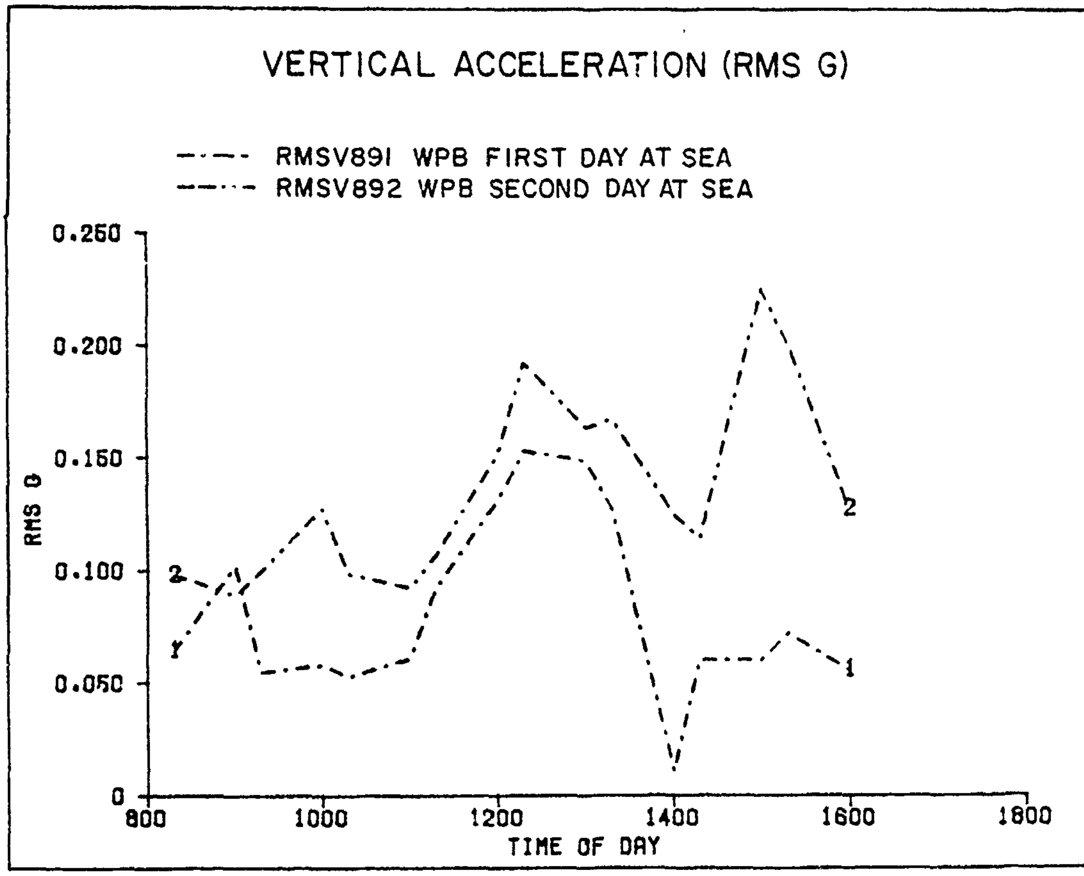


Figure G-4. Vertical single amplitude accelerations aboard the WPB.

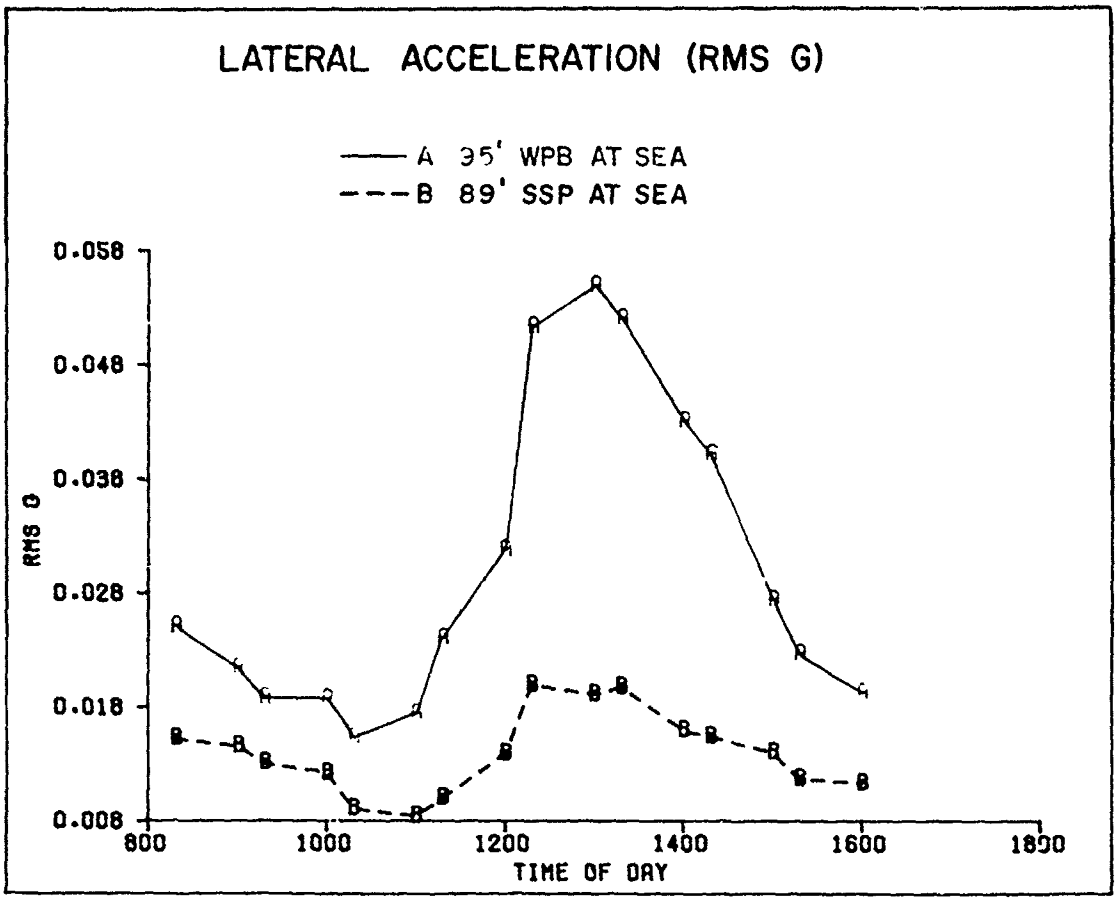


Figure G-5. Average single amplitude lateral accelerations aboard each vessel.

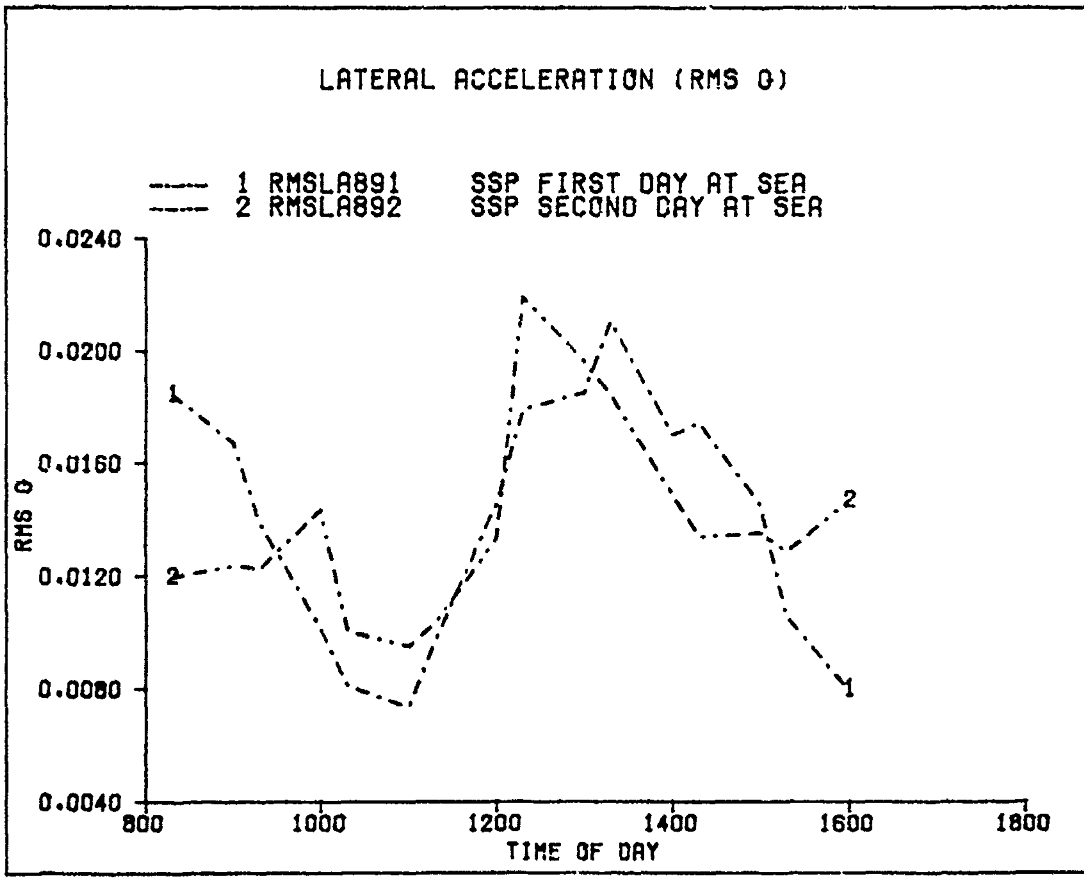


Figure G-6. Lateral single amplitude accelerations aboard the SSP.

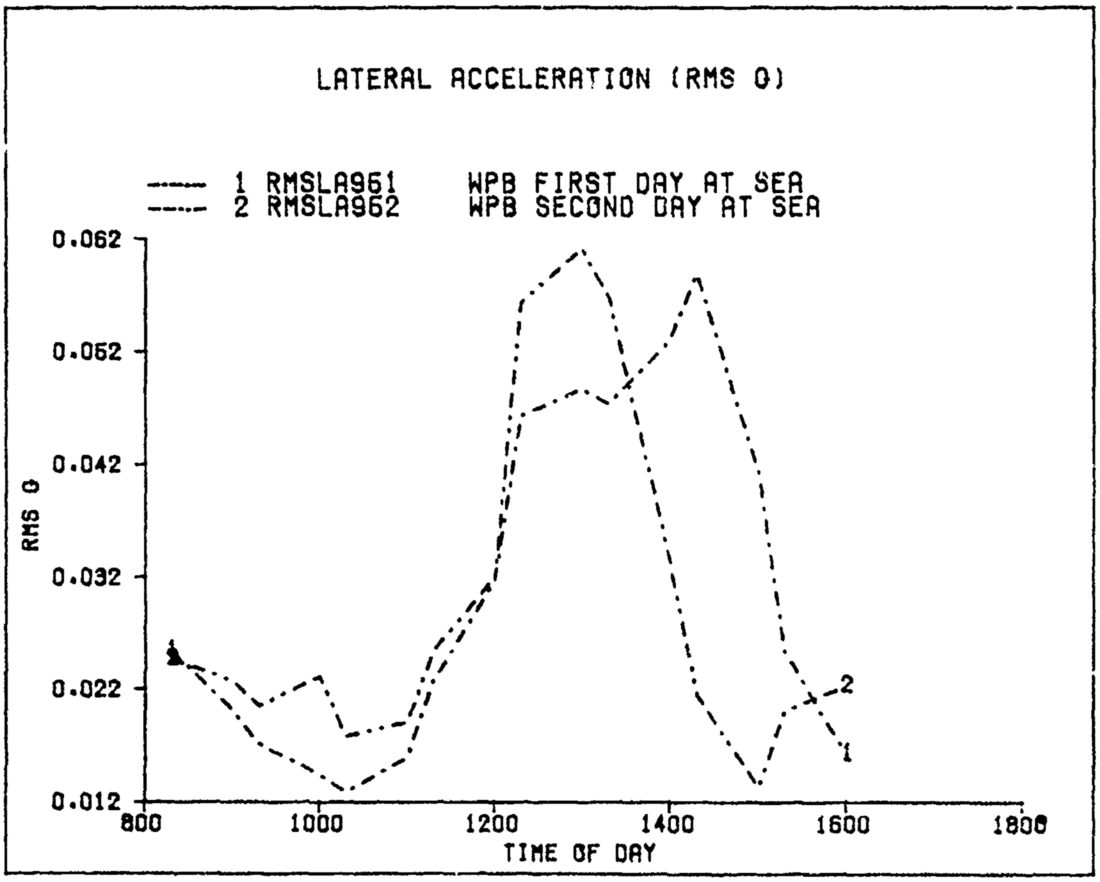


Figure G-7. Lateral single amplitude accelerations aboard the WPB.

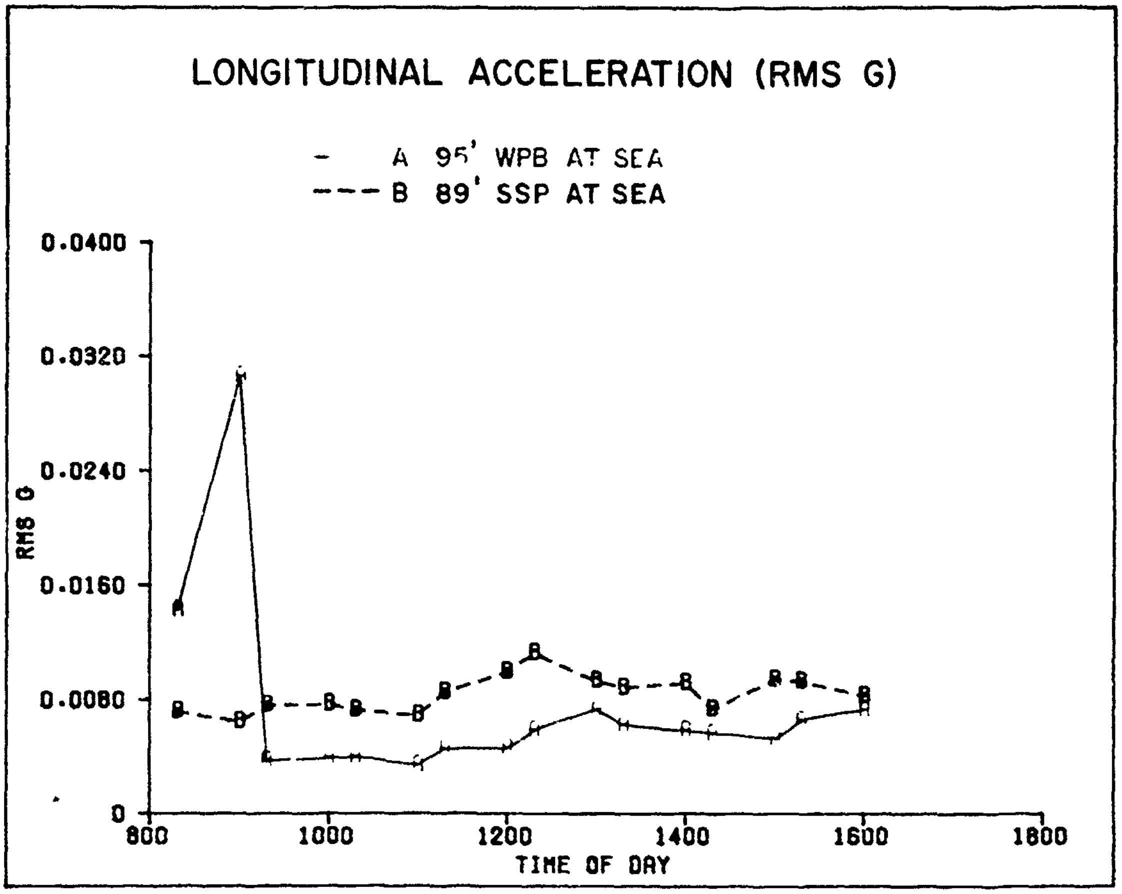


Figure G-8. Average single amplitude longitudinal accelerations aboard each vessel.

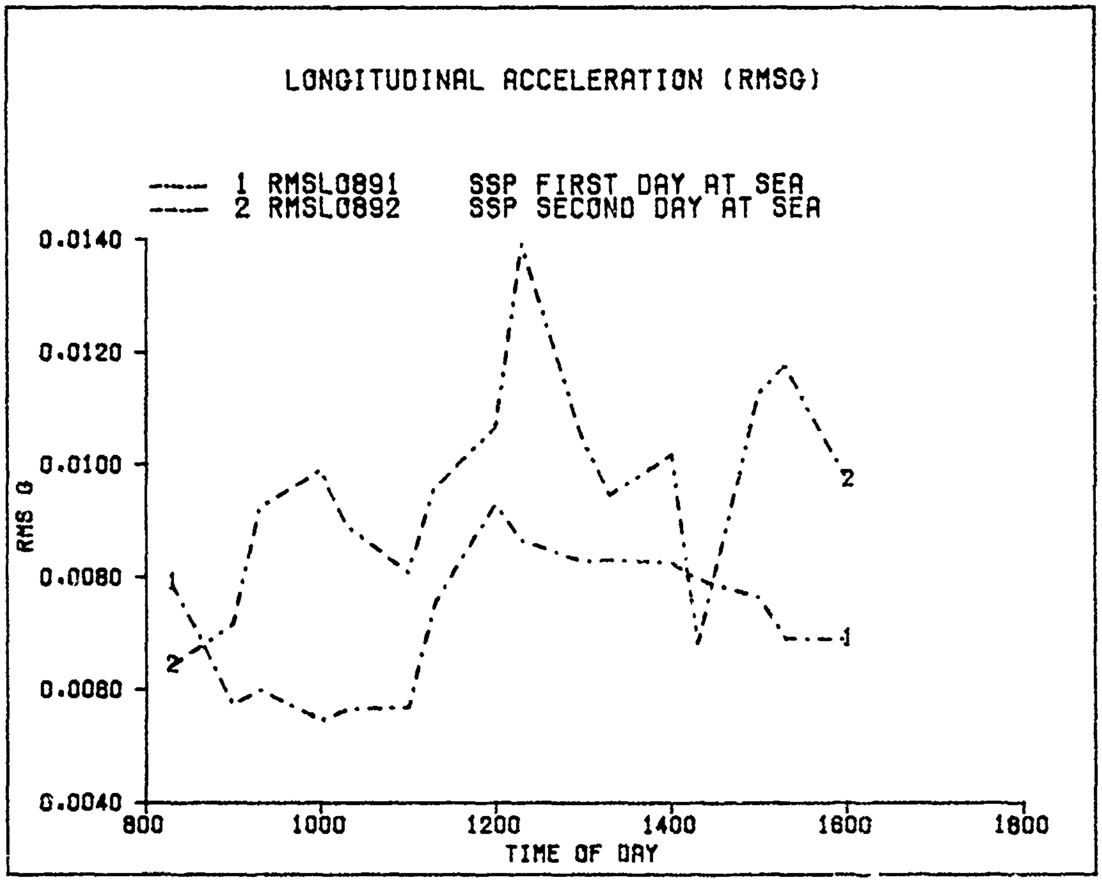


Figure G-9. Longitudinal single amplitude accelerations aboard the SSP.

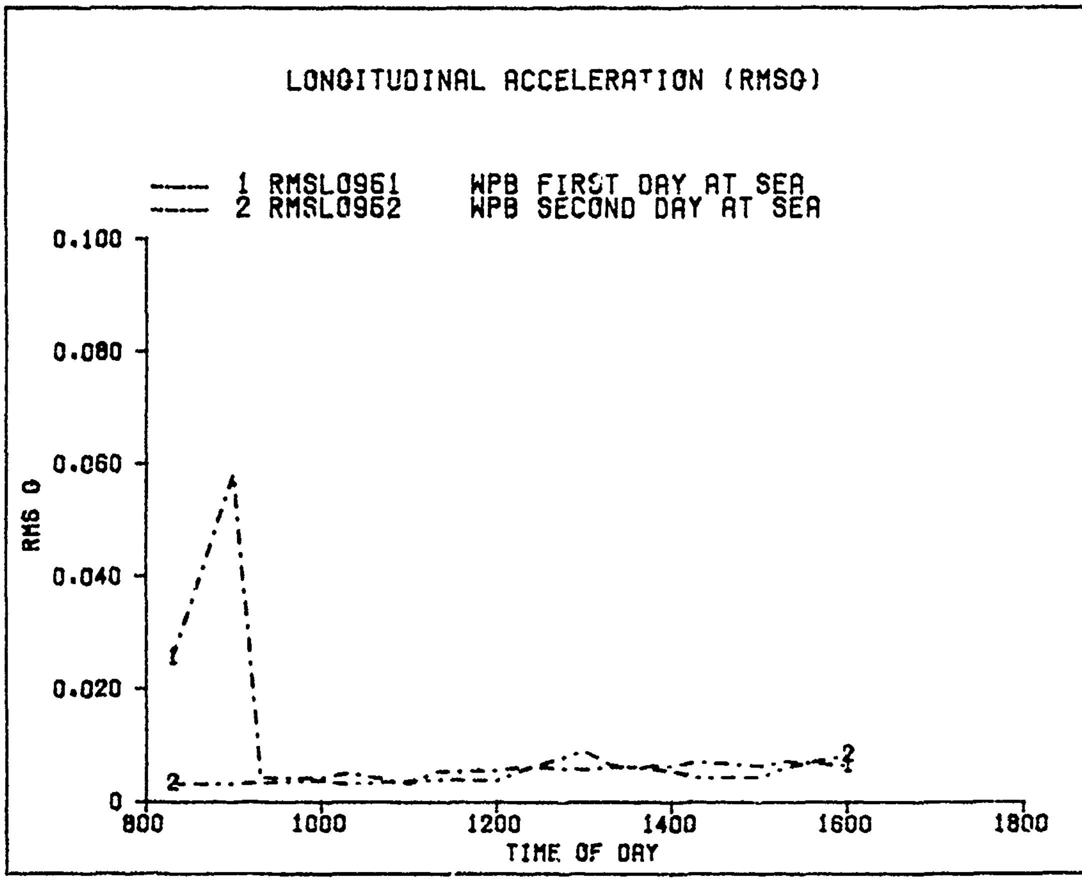


Figure G-10. Longitudinal single amplitude accelerations aboard the WPB.

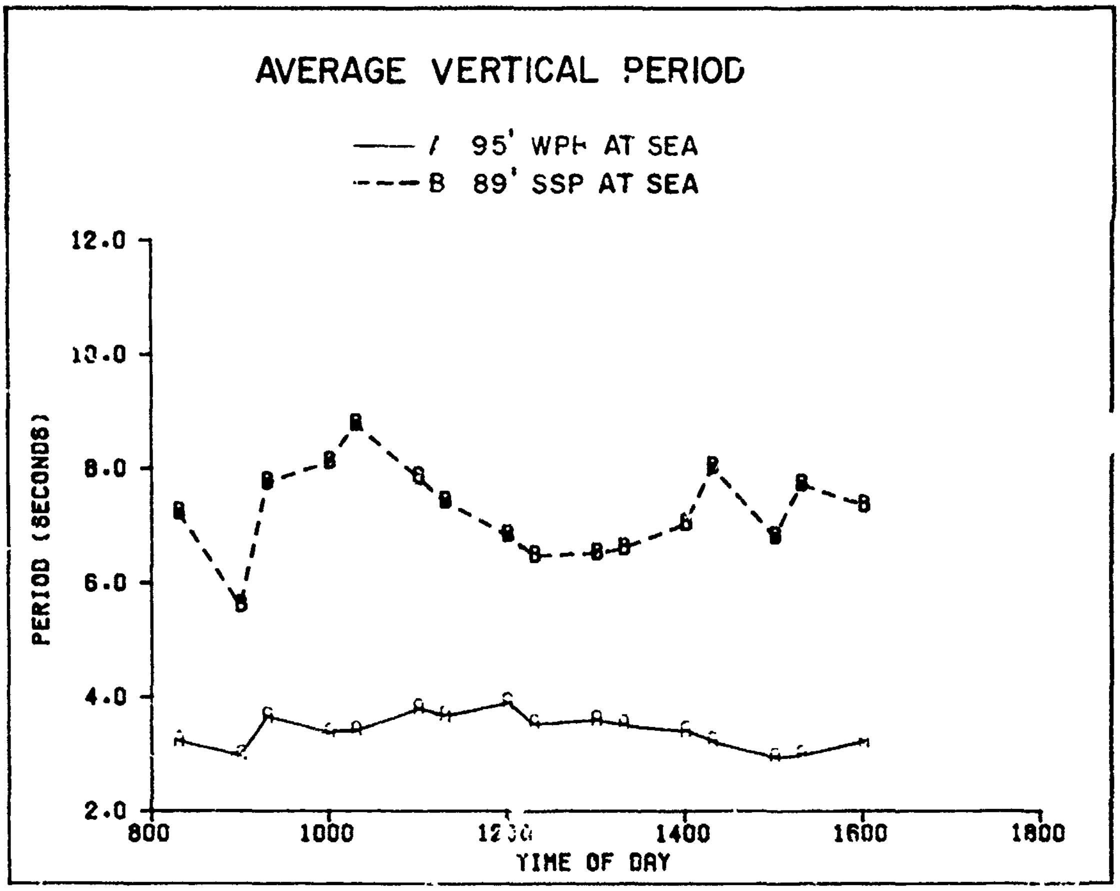


Figure G-11. Average periods of vertical motions abcard each vessel.

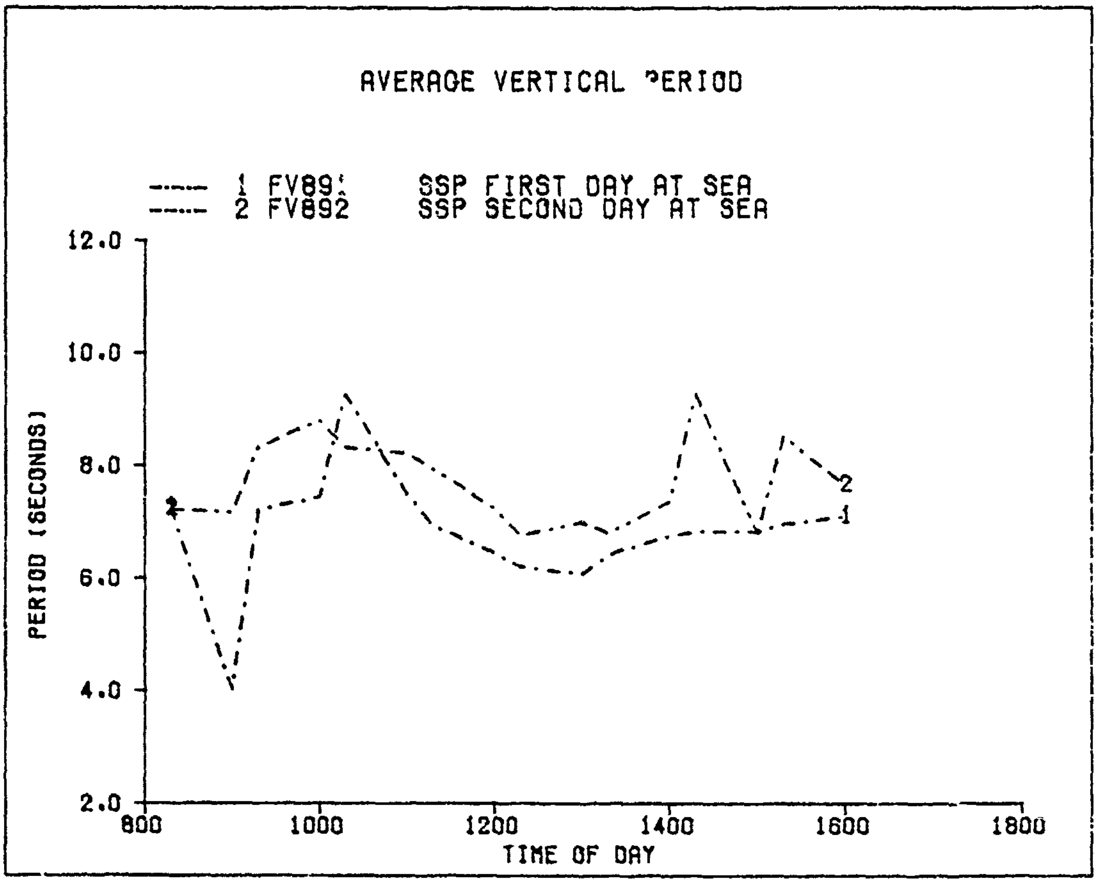


Figure G-12. Periods of vertical motions aboard the SSP.

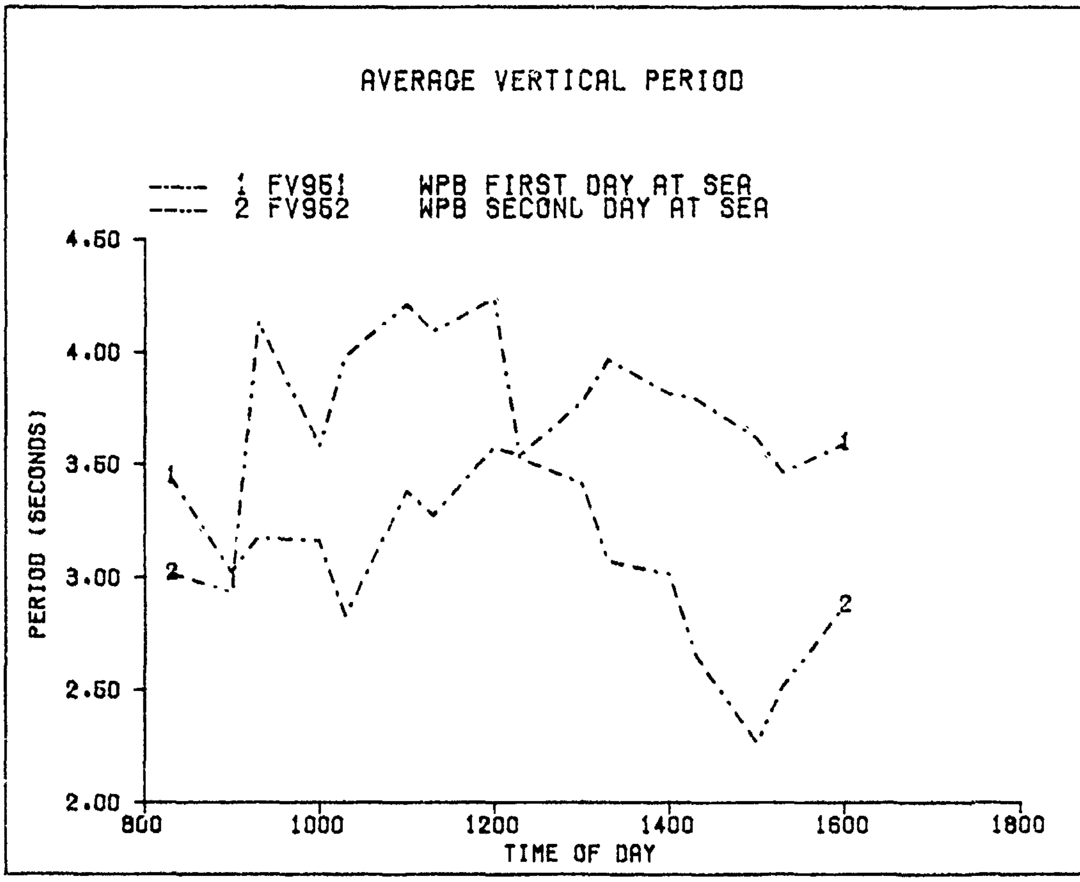


Figure G-13. Periods of vertical motions aboard the WPB.

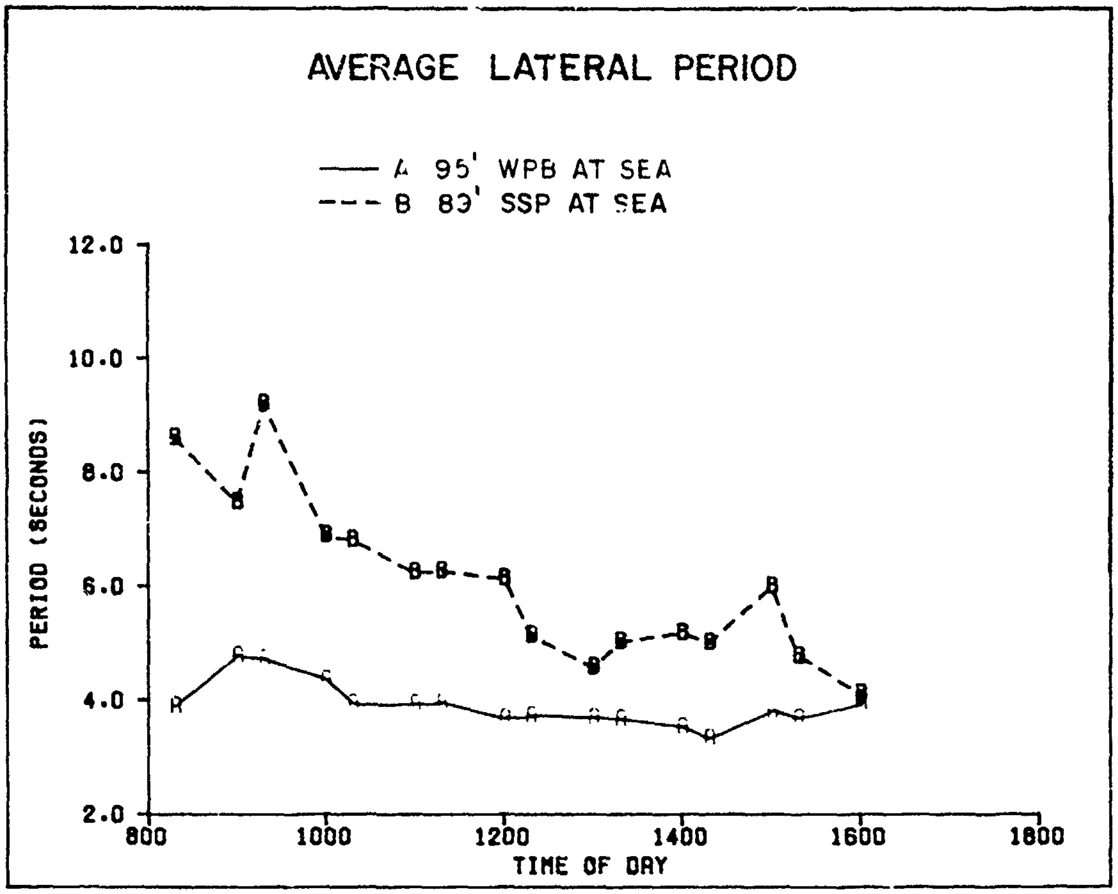


Figure G-14. Average periods of lateral motions aboard each vessel.

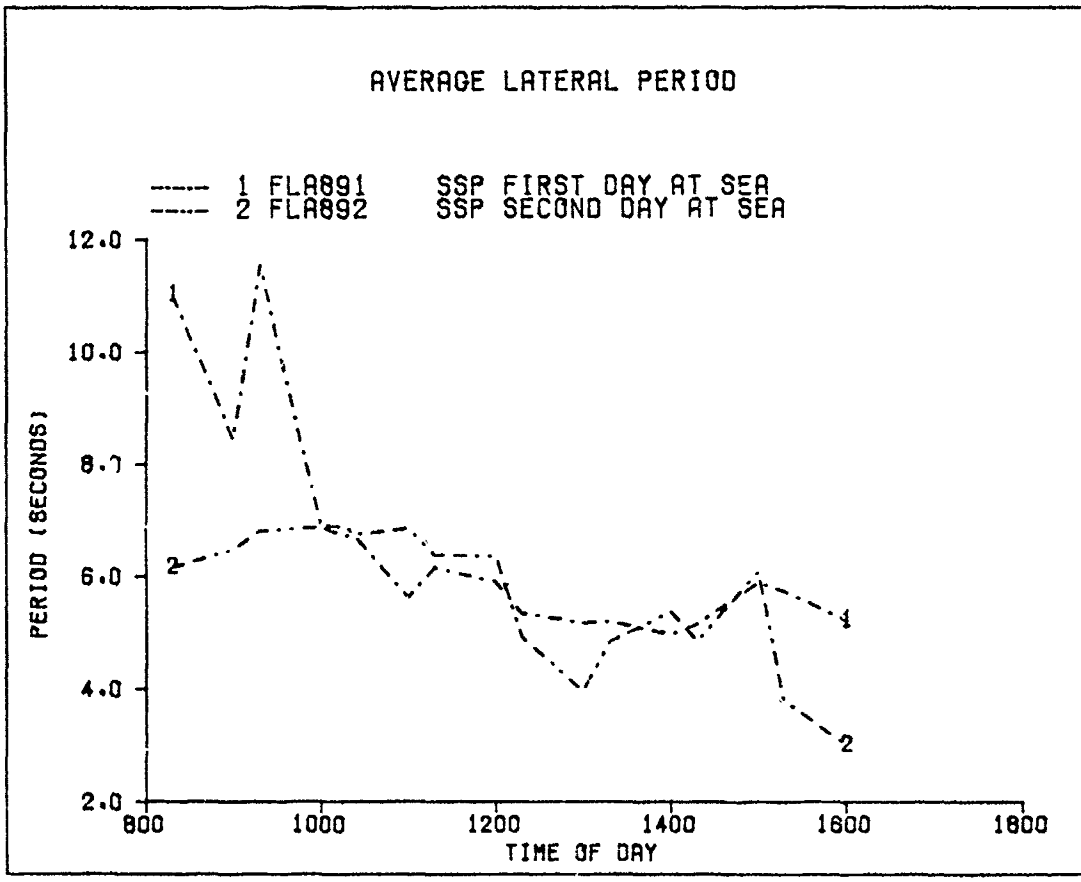


Figure G-15. Periods of lateral motions aboard the SSP.

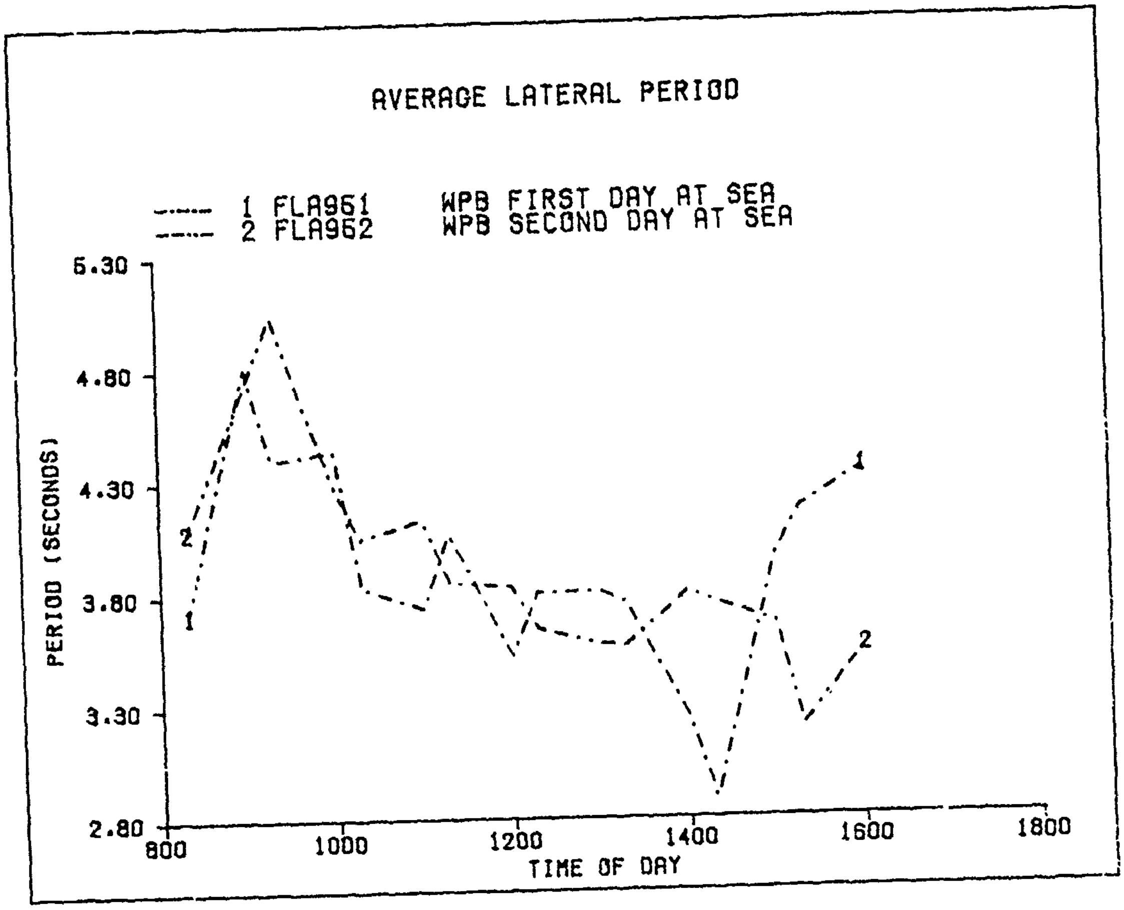


Figure G-16. Periods of lateral motions abaord the WPB.

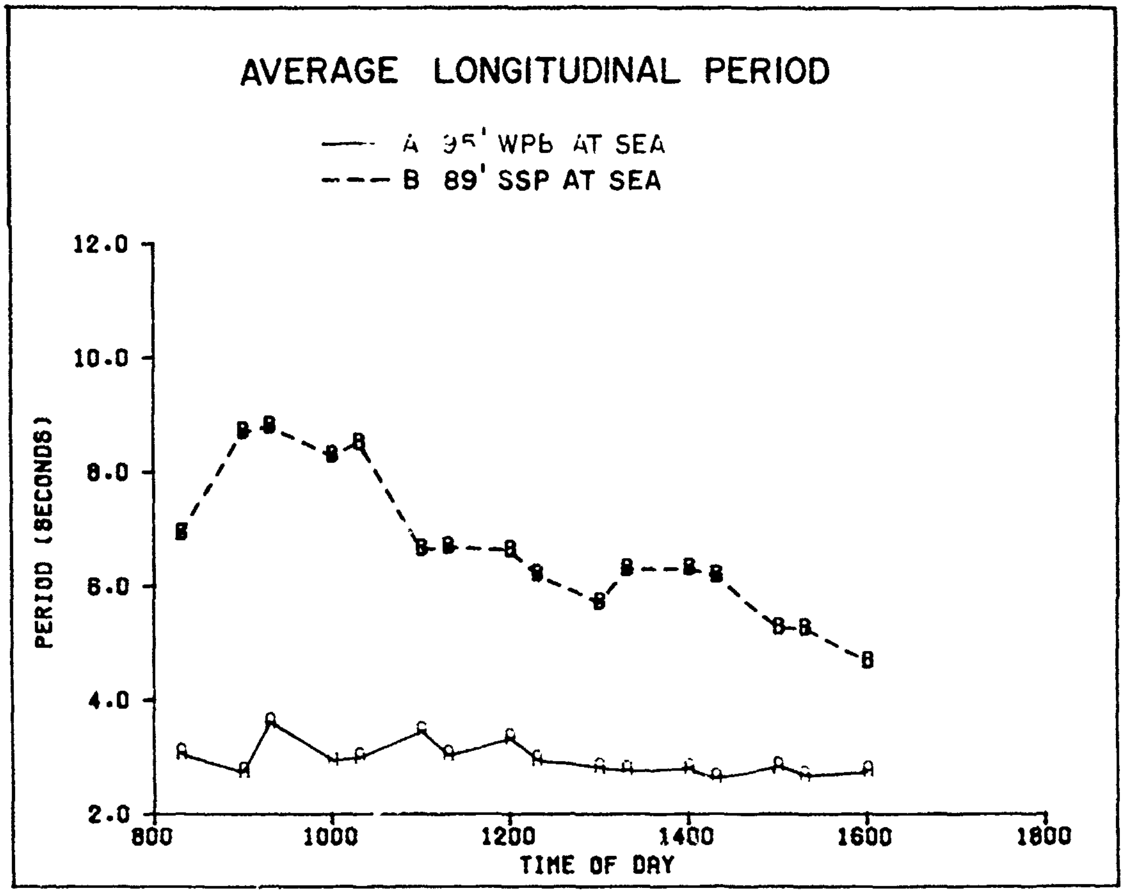


Figure G-17. Average period of longitudinal motions aboard each vessel.

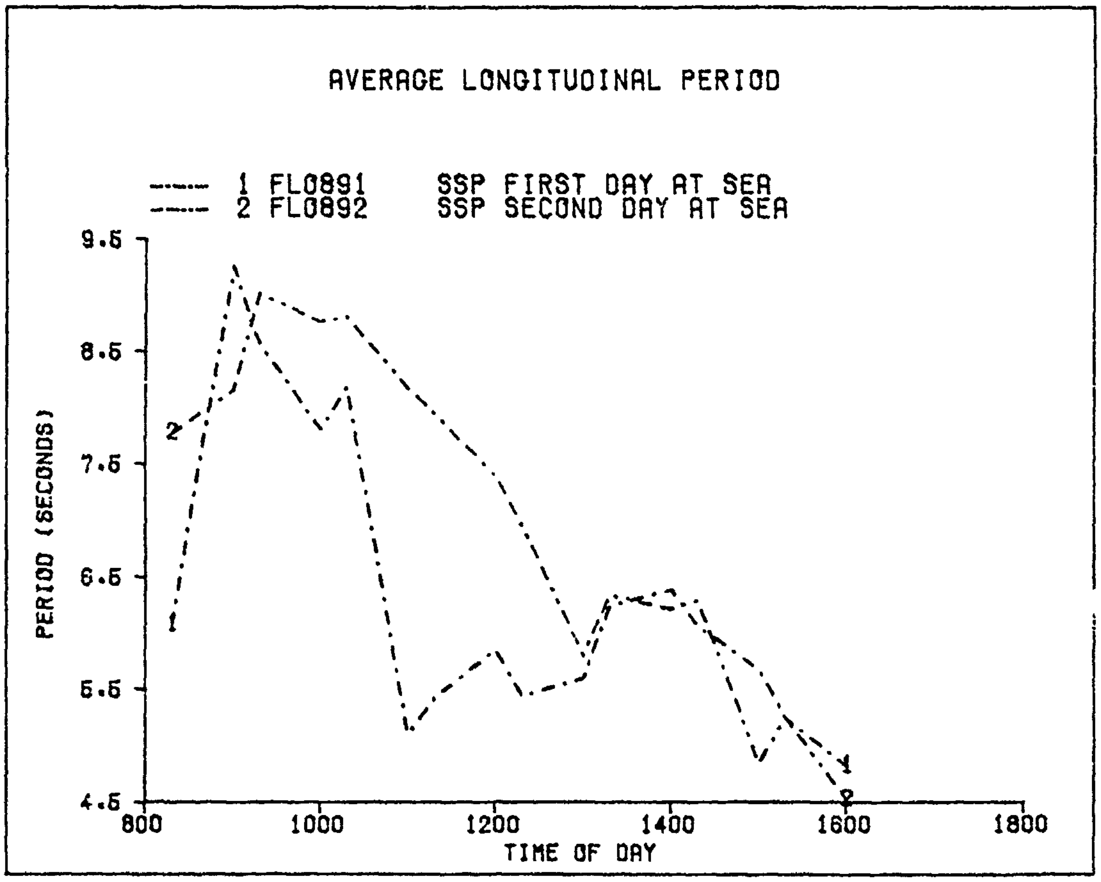


Figure G-18. Periods of longitudinal motions aboard the SSP.

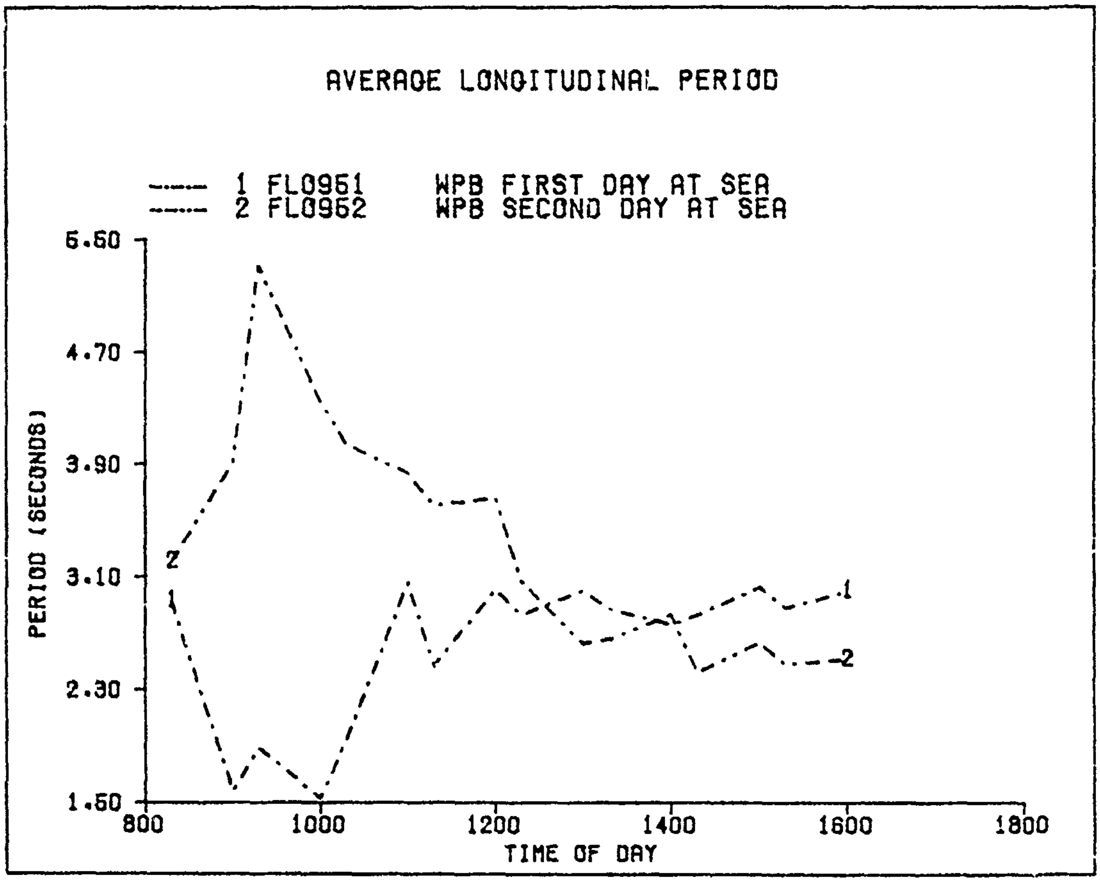


Figure G-19. Periods of longitudinal motions aboard the WPB.

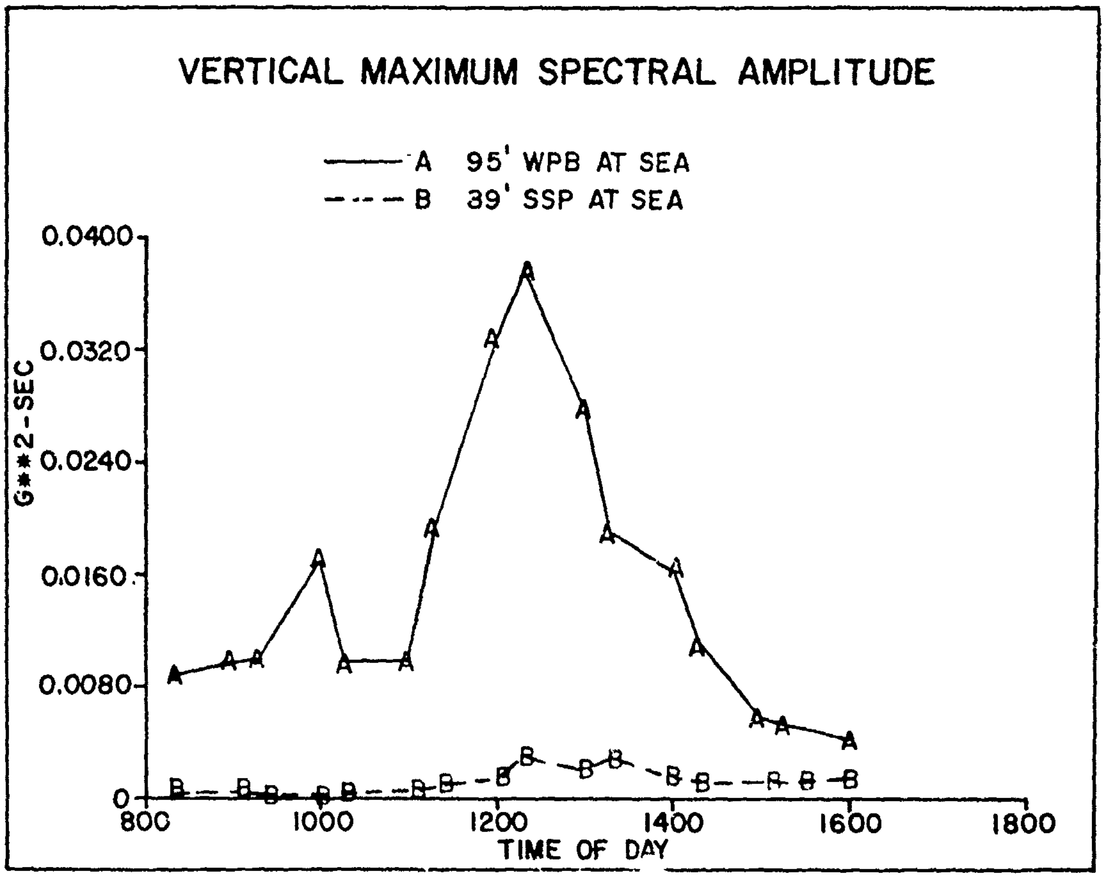


Figure G-20. Average maximum spectral amplitudes of vertical motions aboard each vessel.

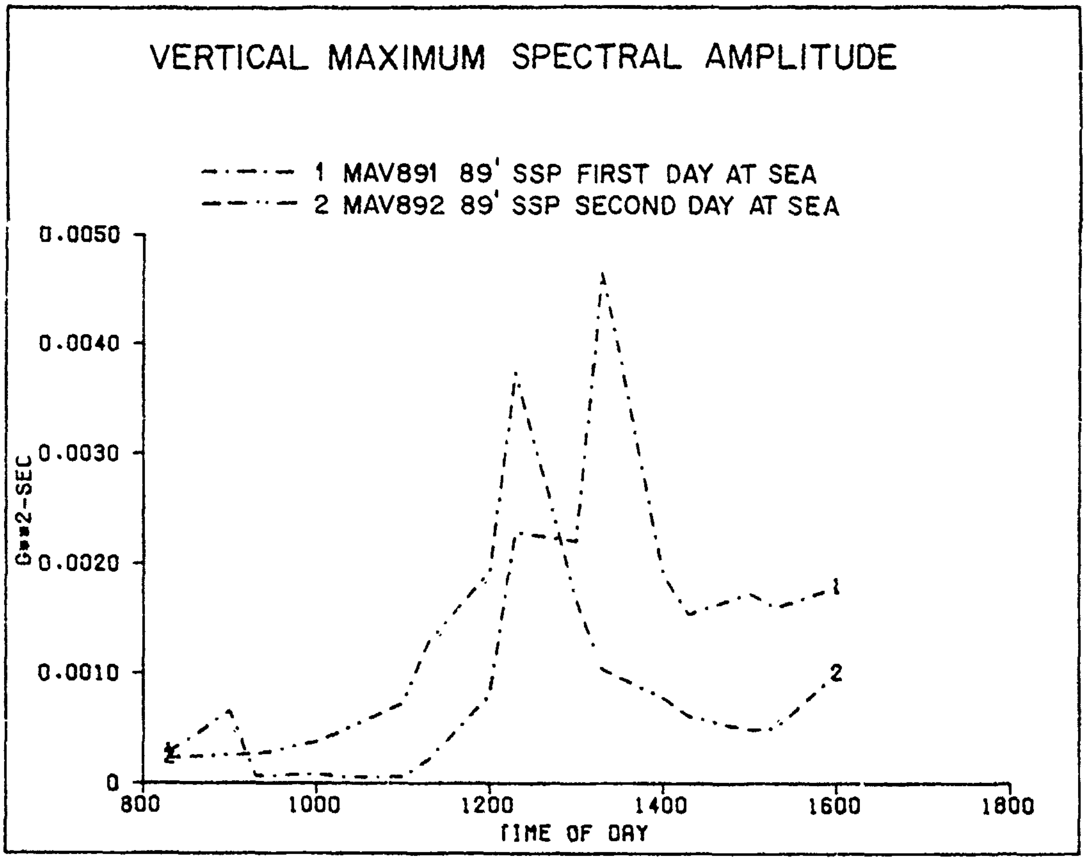


Figure G-21. Maximum spectral amplitudes of vertical motions aboard the SSP.

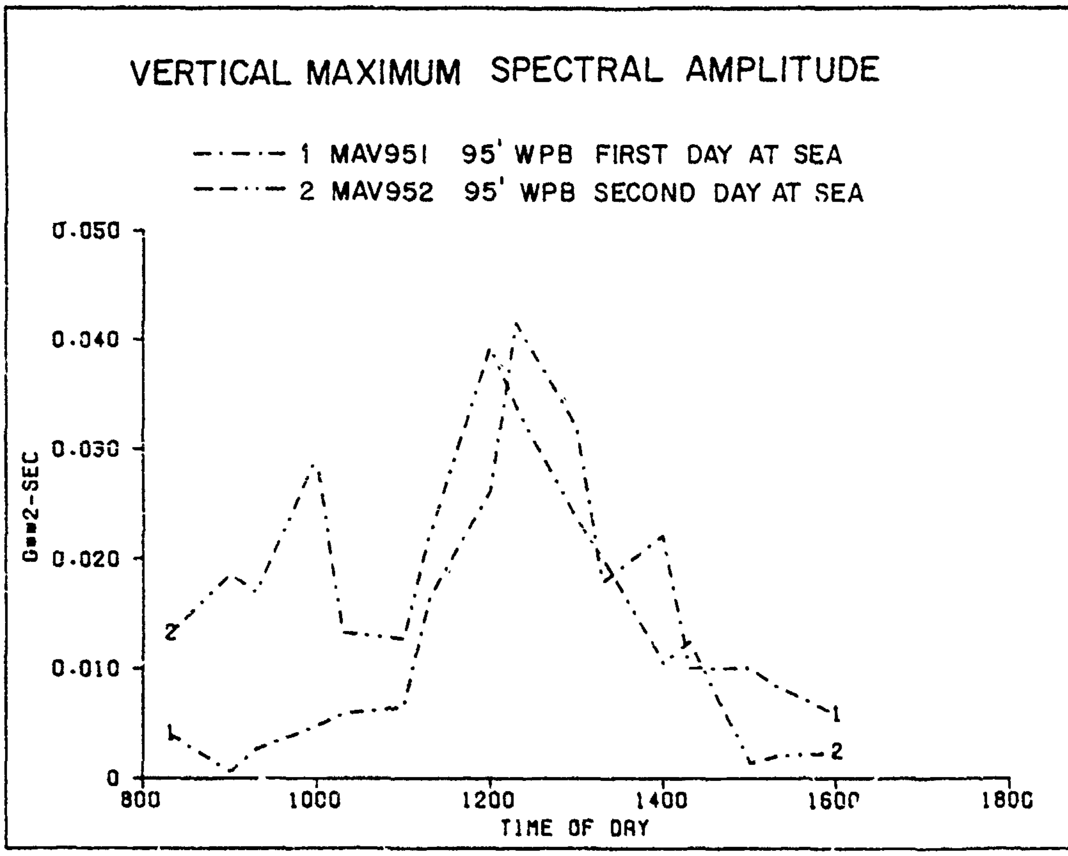


Figure G-22. Maximum spectral amplitudes of vertical motions aboard the WPB.

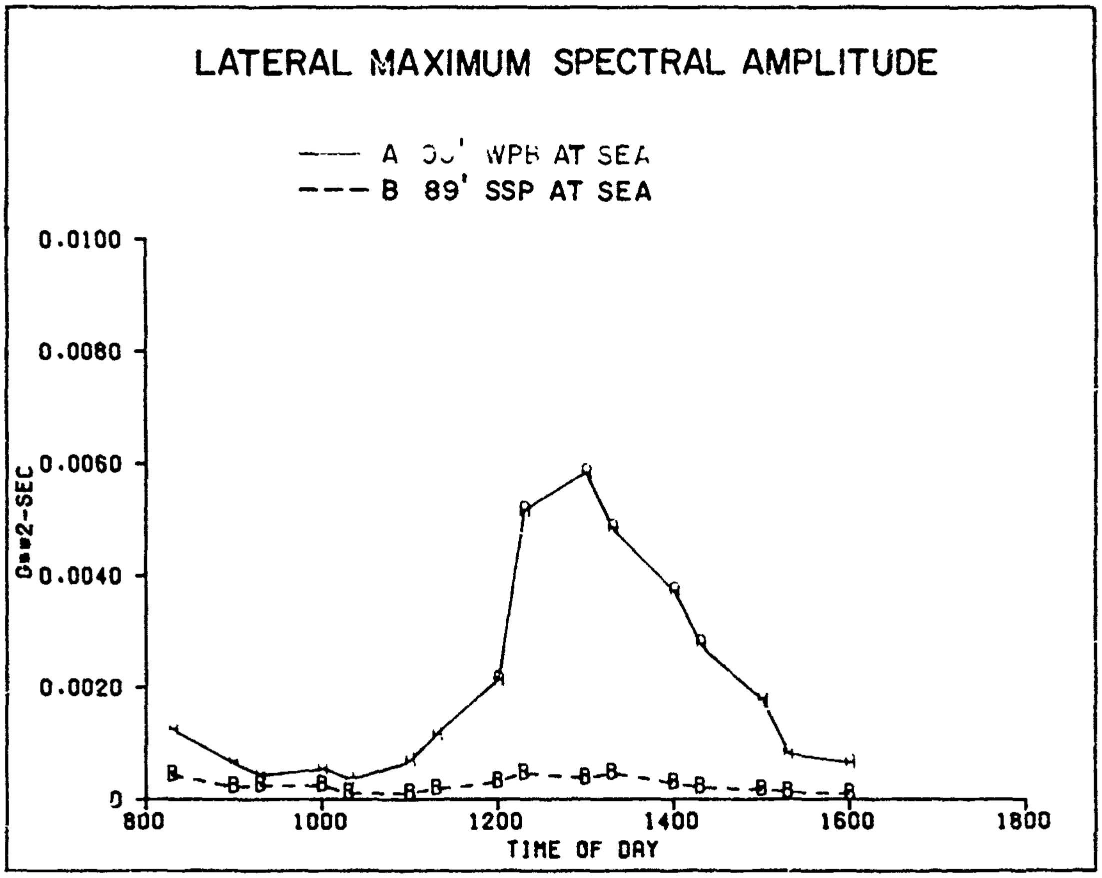


Figure G-23. Average maximum spectral amplitudes of lateral motions aboard each vessel.

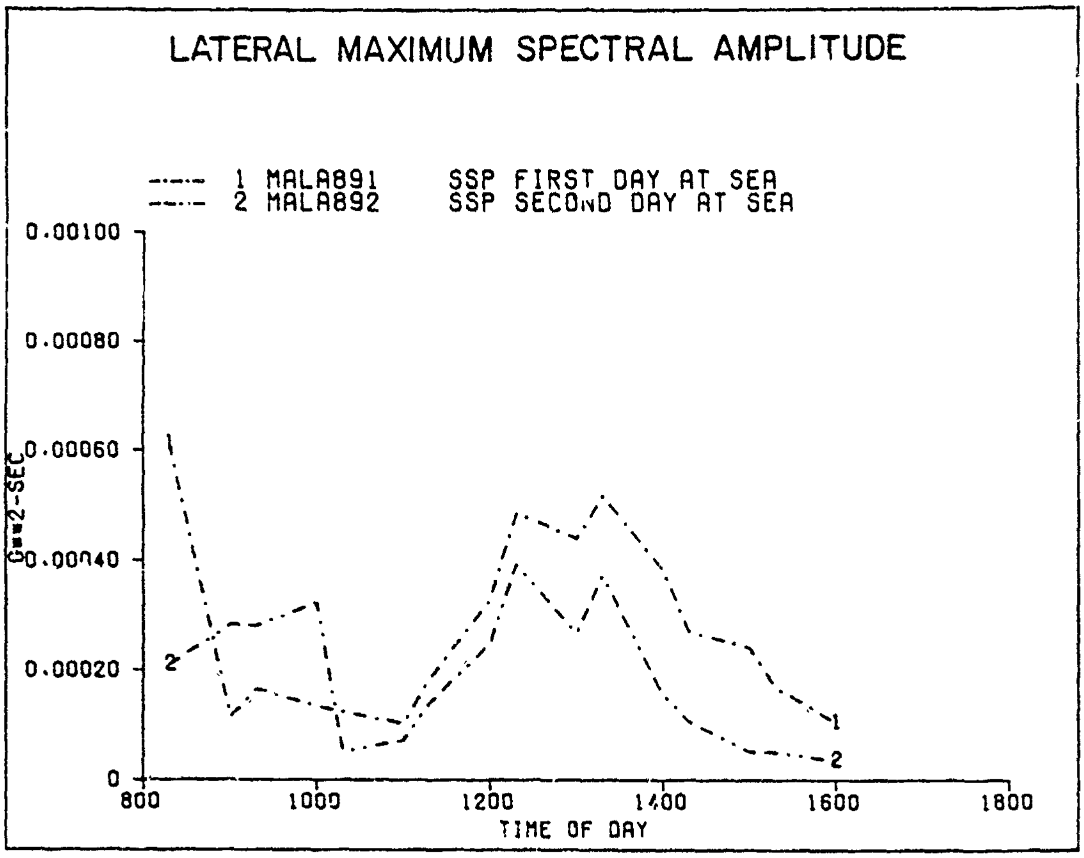


Figure G-24. Maximum spectral amplitudes of lateral motions aboard the SSP.

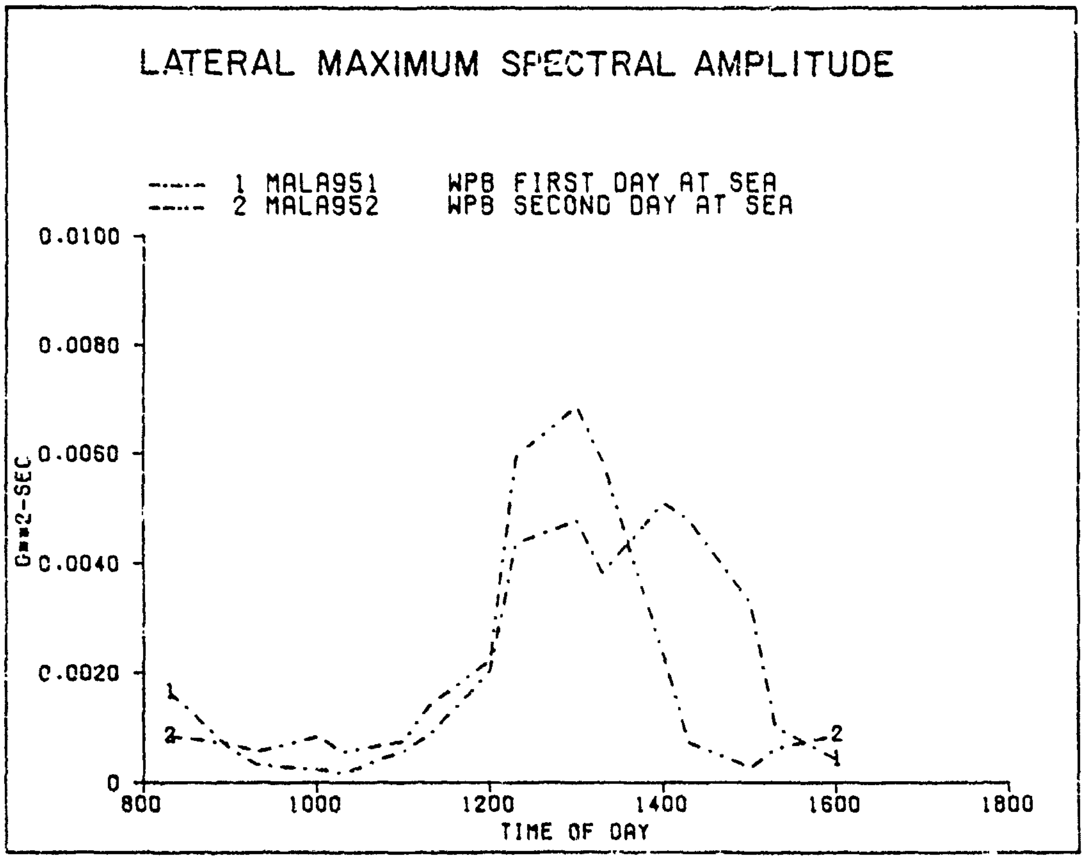


Figure G-2F. Maximum spectral amplitudes of lateral motions aboard the WPB.

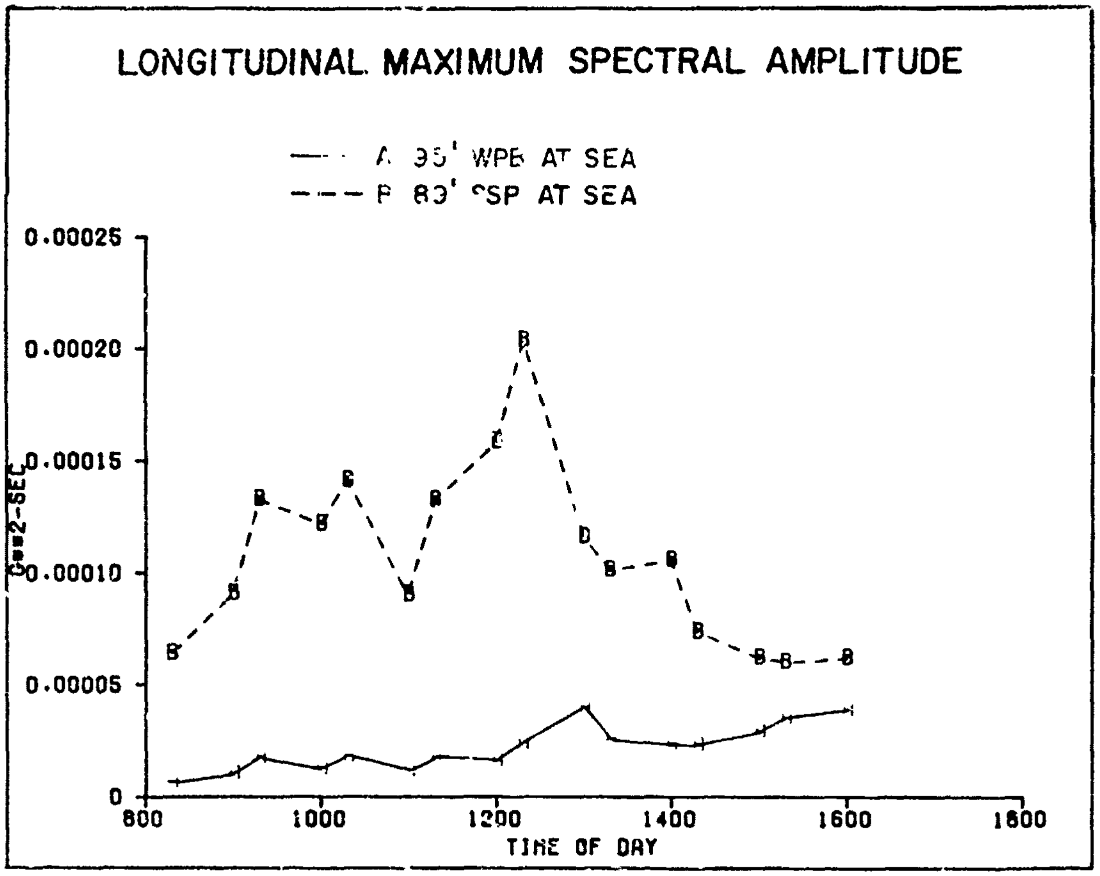


Figure G-26. Average maximum spectral amplitudes of longitudinal motions aboard each vessel.

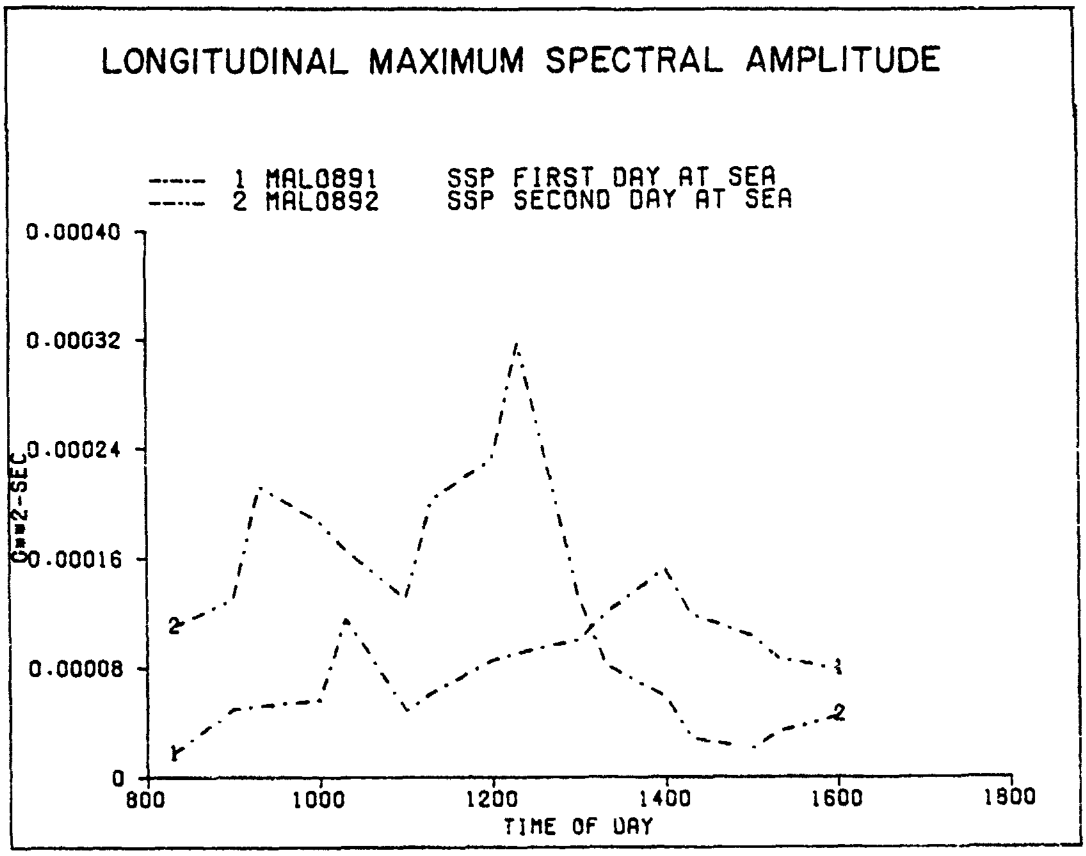


Figure G-27. Maximum spectral amplitudes of longitudinal motions aboard the SSP.

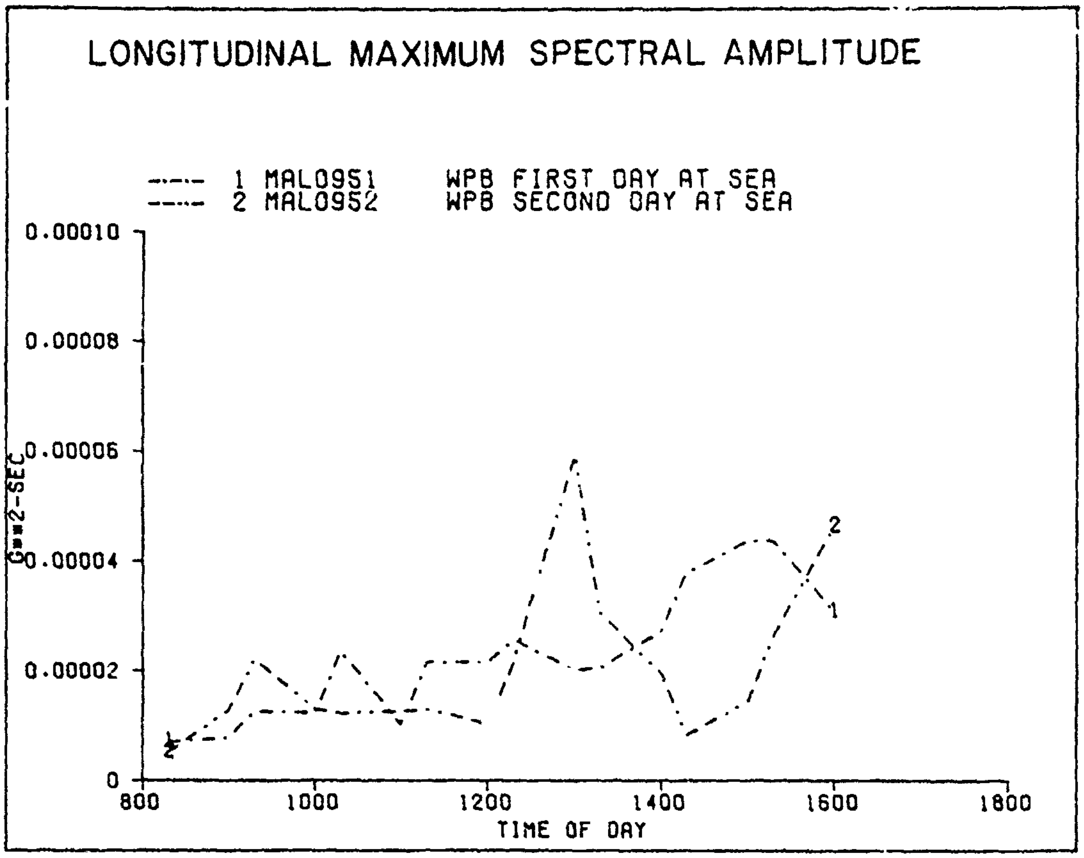


Figure G-28. Maximum spectral amplidtudes of longitudinal motions aboard the WPB.

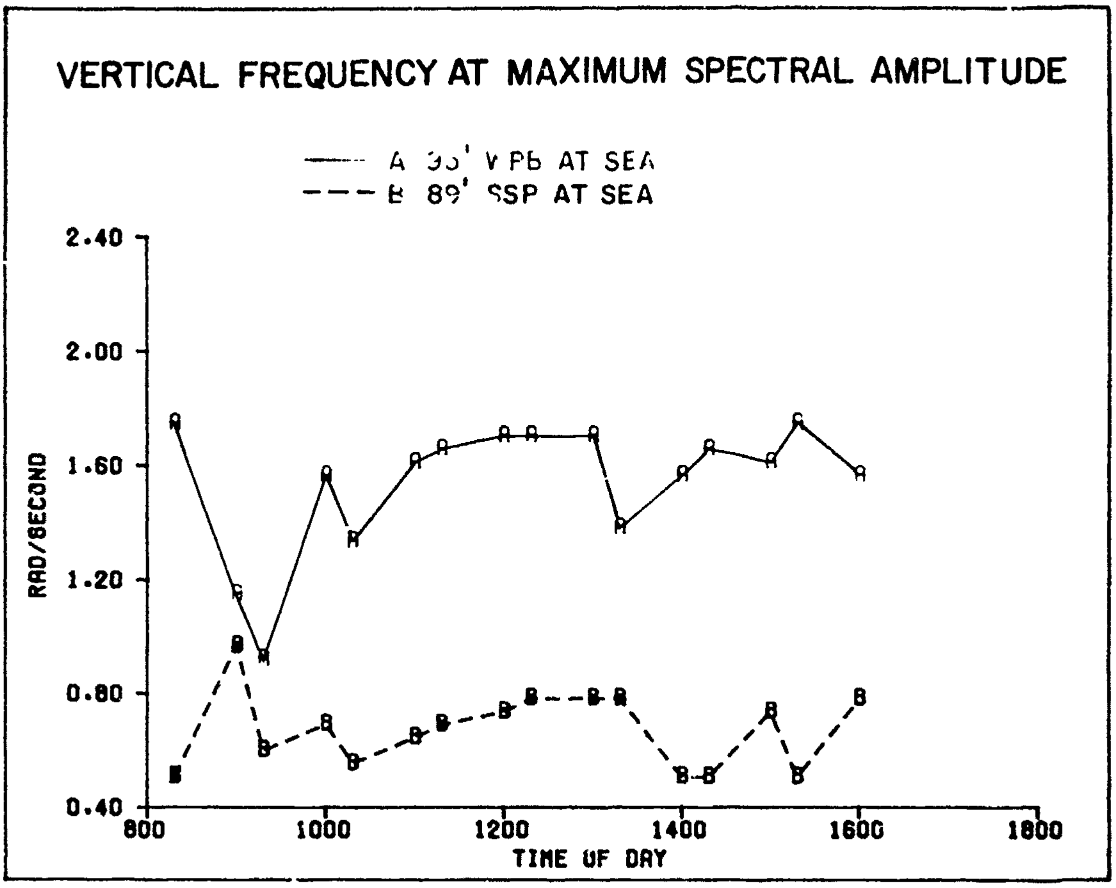


Figure G-29. Average frequency at maximum spectral amplitudes of vertical motions aboard each vessel.

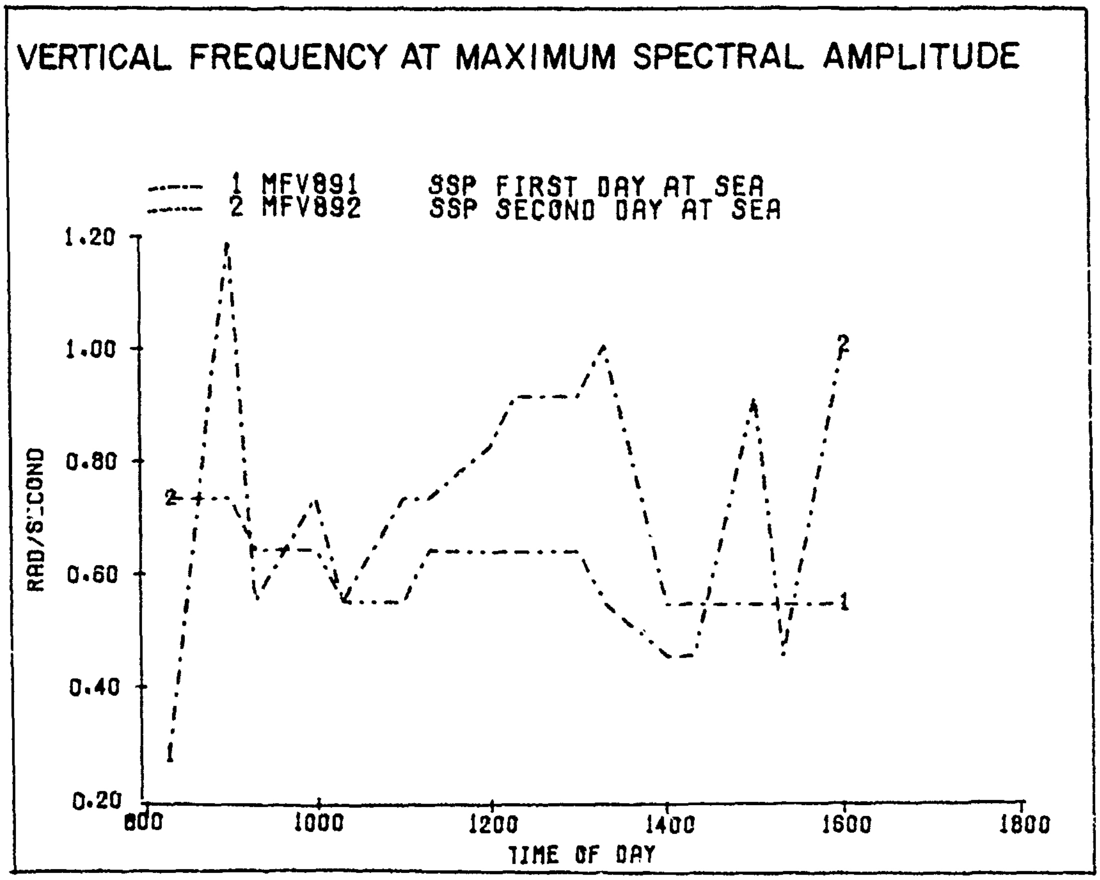


Figure G-30. Frequency at maximum spectral amplitudes of vertical motions aboard the SSP.

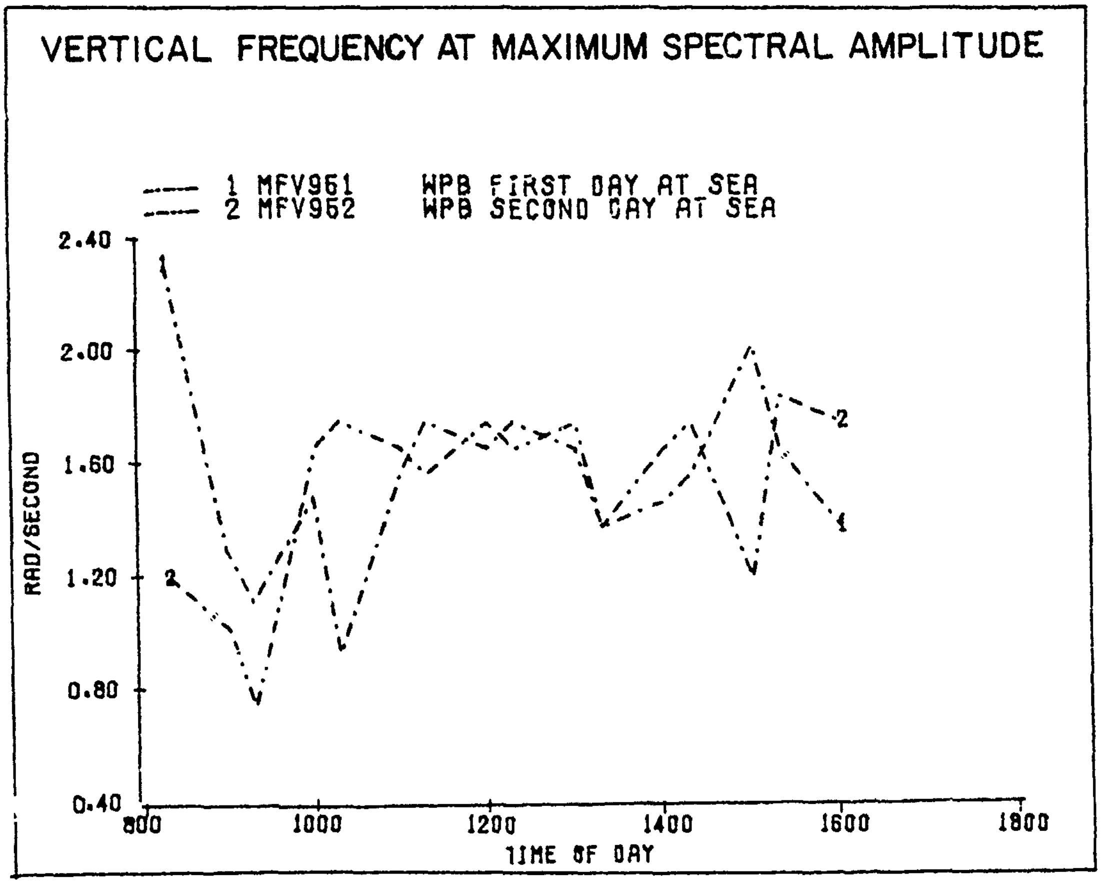


Figure G-31. Frequency at maximum spectral amplitudes of vertical motions aboard the WPB.

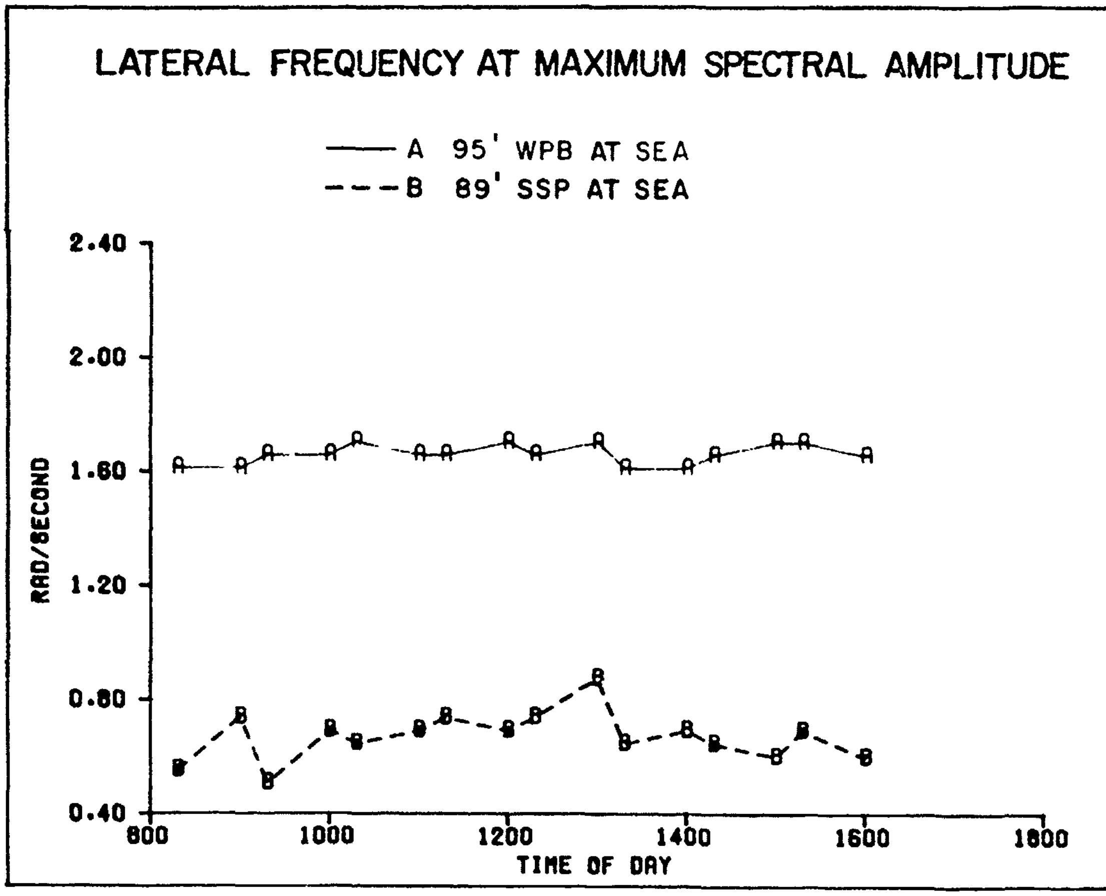


Figure G-32. Average frequency at maximum spectral amplitudes of lateral motions aboard each vessel.

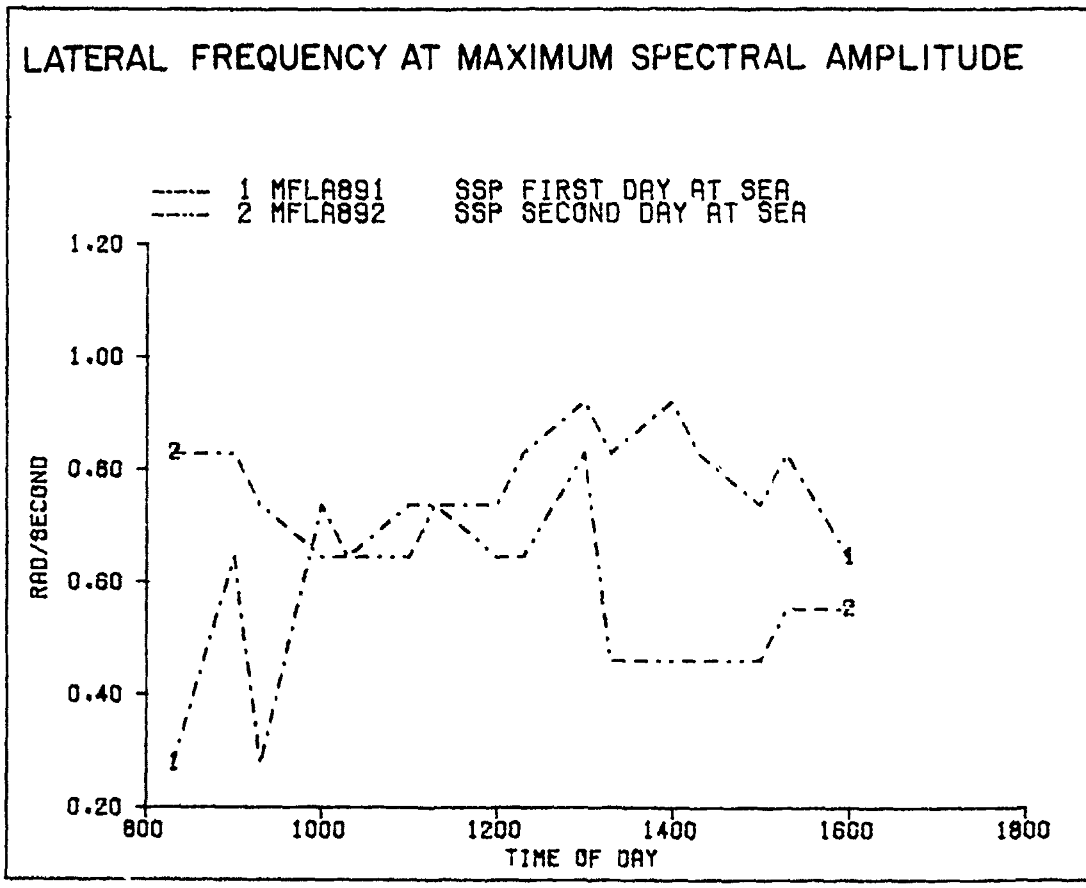


Figure G-33. Frequencies at maximum spectral amplitudes of lateral motions aboard the SSP.

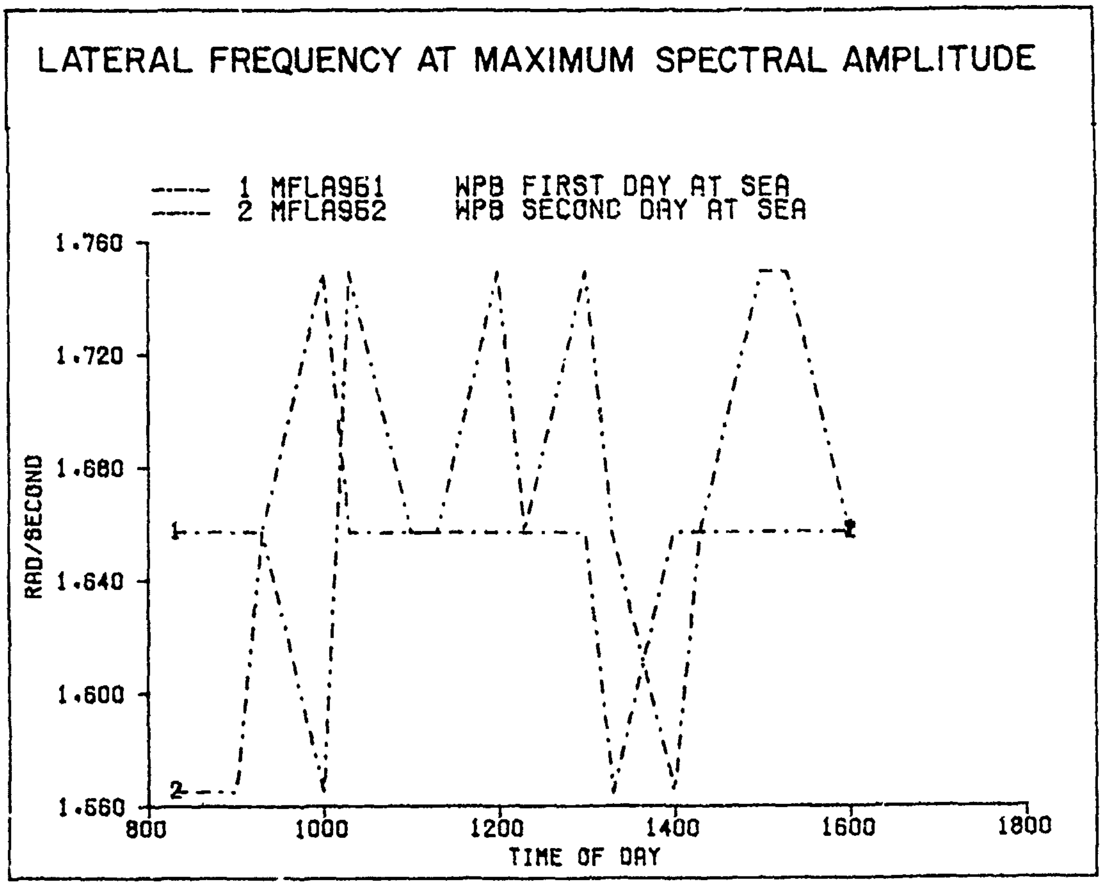


Figure G-34. Frequencies at maximum spectral amplitudes of lateral motions aboard the WPB.

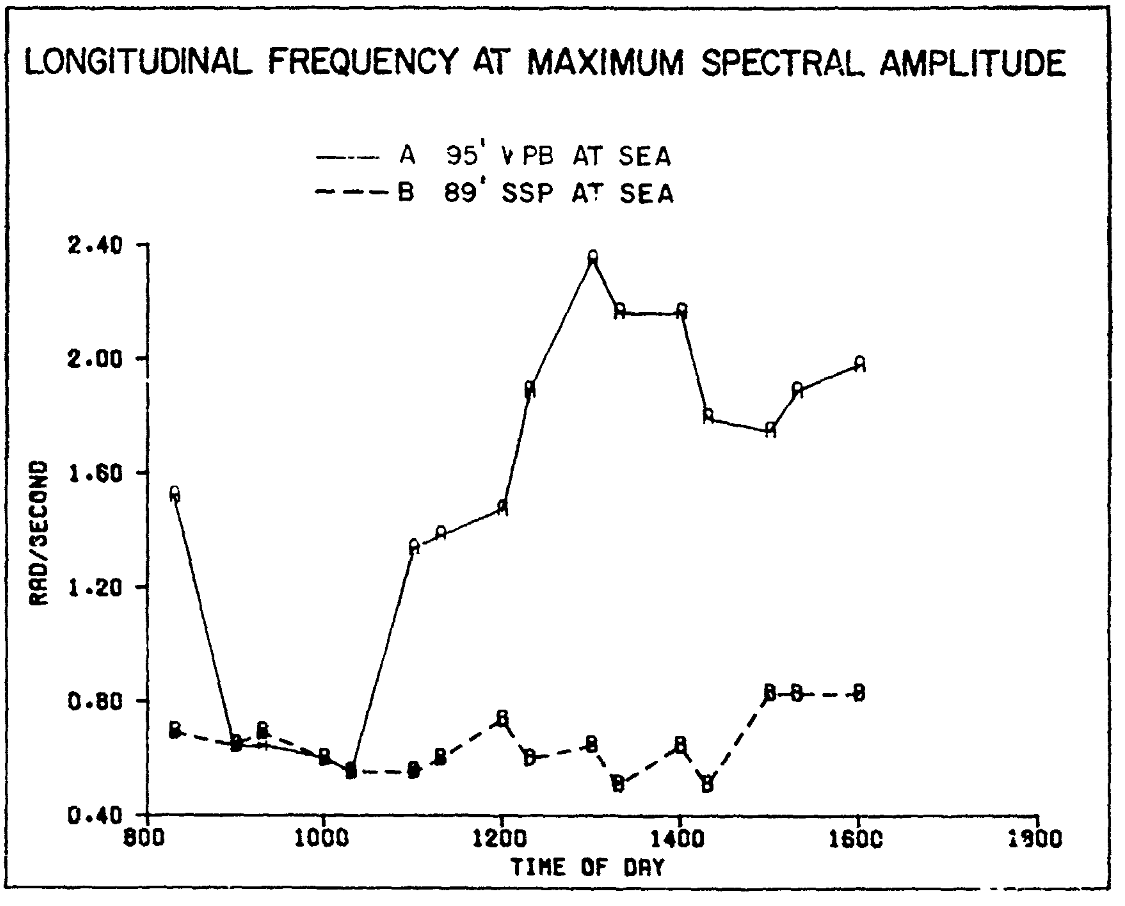


Figure G-35. Average frequency at maximum spectral amplitudes of longitudinal motions aboard each vessel.

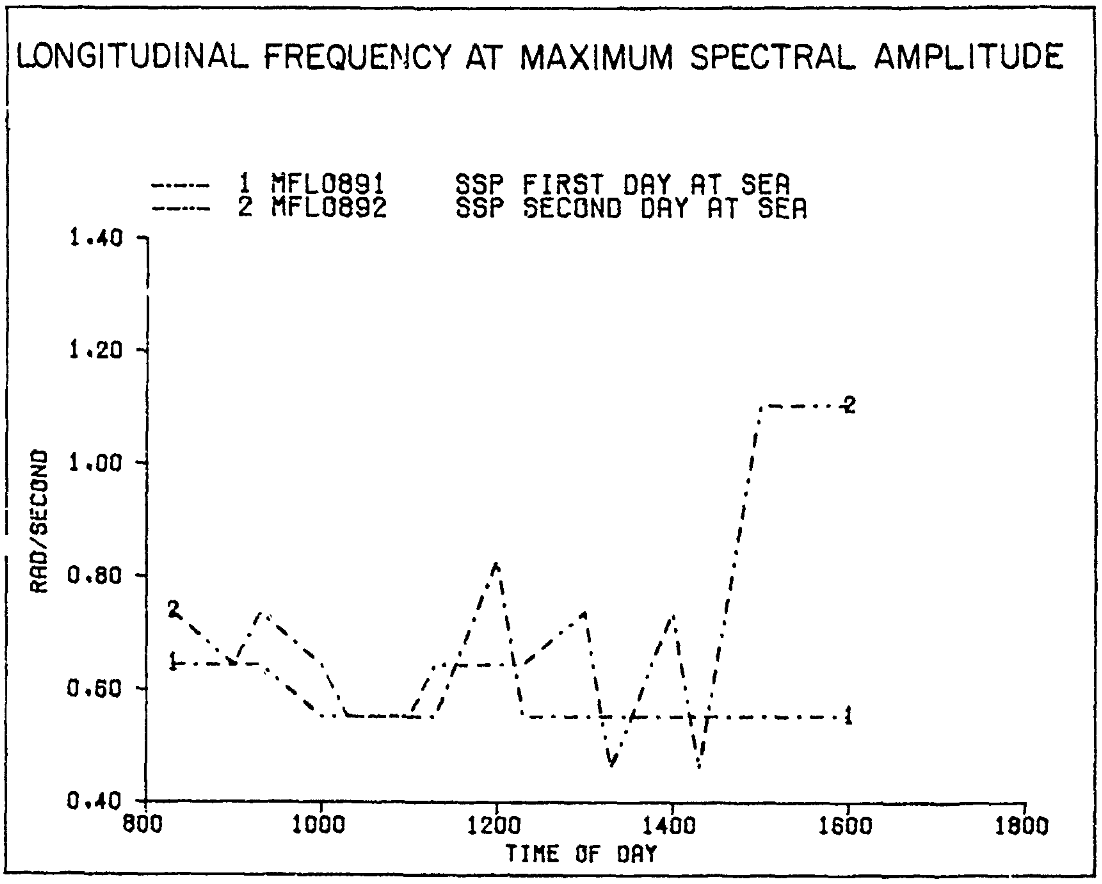


Figure G-36. Frequency at maximum spectral amplitudes of longitudinal motions aboard the SSP.

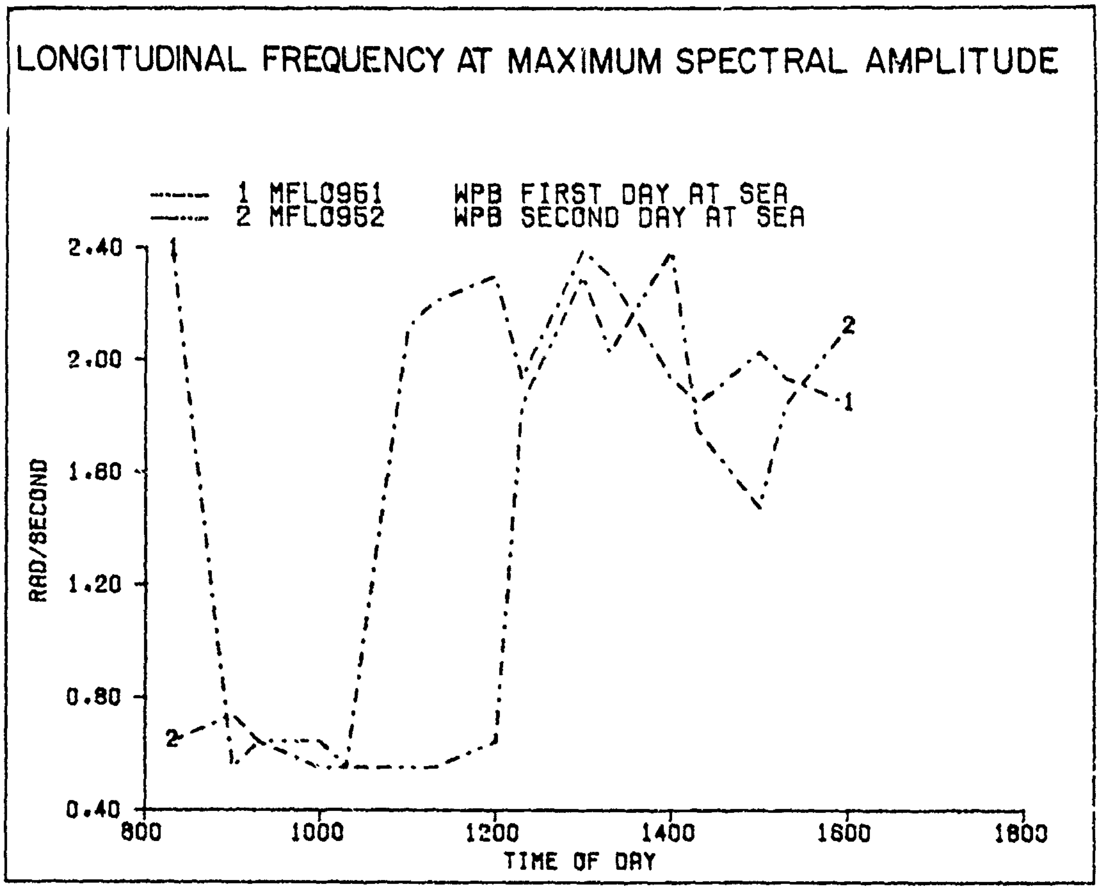


Figure G-37. Frequency at maximum spectral amplitudes of longitudinal motions aboard the WPB.

APPENDIX H

Definitions of Sea State Conditions

APPENDIX H

DEFINITIONS OF SEA STATE CONDITIONS: WAVE AND SEA FOR FULLY ARISEN SEA

Sea—General		Wind				Sea								
Sea State	Description	(Beaufort) Wind force	Description	Range (knots)	Wind Velocity (knots)	Wave Height: Average	Wave Height: Significant	Wave Height: Average of One-Tenth Highest	Significant Range of Periods (sec)	Periods of maximum Energy of Spectra $T_{max} = T_c$	Average Period $\bar{T}_c$	Average Wave-length $\bar{L}_w$ [ft unless otherwise indicated]	Minimum Fetch (nautical miles)	Minimum Duration [hr unless otherwise indicated]
	Sea like a mirror	0	Calm	<1	0	0	0	0	—	—	—	—	—	—
0	Ripples with the appearance of scales are formed, but without foam crests.	1	Light airs	1–3	2	0.04	0.01 0.01	0.09	1.2	0.75	0.5	10 in.	5	18 min.
1	Small wavelets, short but pronounced crests have a glossy appearance, but do not break.	2	Light breeze	4–6	5	0.3	0.5	0.6	0.4–2.8	1.9	1.3	6.7 ft	8	39 min.
	Large wavelets, crests begin to break. Foam of glossy appearance. Perhaps scattered white horses.	3	Gentle breeze	7–10	8.5	0.8	1.3	1.6	0.8–5.0	3.2	2.3	20	9.8	1.7
					10	1.1	1.8	2.3	1.0–6.0	3.2	2.7	27	10	2.4
2	Small waves, becoming larger; fairly frequent white horses.	4	Moderate breeze	11–16	12	1.6	2.6	3.3	1.0–7.0	4.5	3.2	40	18	3.8
					13.5	2.1	3.3	4.2	1.4–7.6	5.1	3.6	52	24	4.8
					14	2.3	3.6	4.6	1.5–7.8	5.3	3.8	59	28	5.2
3					16	2.9	4.7	6.0	2.0–8.8	6.0	4.3	71	40	6.6
					18	3.7	5.9	7.5	2.5–10.0	6.8	4.8	90	55	8.3
4	Moderate waves, taking a more pronounced long form; many white horses are formed (chance of some spray).	5	Fresh breeze	17–21	19	4.1	6.6	8.4	2.8–10.6	7.2	5.1	99	65	9.2
					20	4.6	7.3	9.3	3.0–11.1	7.5	5.4	111	75	10
5					22	5.5	8.8	11.2	3.4–12.2	8.3	5.9	134	100	12
	Large waves begin to form; white crests are more extensive everywhere (probably some spray).	6	Strong breeze	22–27	24	6.6	10.5	13.3	3.7–13.5	9.0	6.4	160	130	14
					24.5	6.8	10.9	13.8	3.8–13.6	9.2	6.6	164	140	15
6					26	7.7	12.3	15.6	4.0–14.5	9.8	7.0	188	180	17
					28	8.9	14.3	18.2	4.5–15.5	10.6	7.5	212	230	20
	Sea heaps up, and white foam from breaking waves begins to be blown in streaks along the direction of the wind (Spindrift begins to be seen).	7	Moderate gale	28–33	30	10.3	16.4	20.8	4.7–16.7	11.3	8.0	250	280	23
					30.5	10.6	16.9	21.5	4.8–17.0	11.5	8.2	258	290	24
7					32	11.6	18.6	23.6	5.0–17.5	12.1	8.6	285	340	27
					34	13.1	21.0	26.7	5.5–18.5	12.8	9.1	322	420	30
7					36	14.8	23.6	30.0	5.8–19.7	13.6	9.6	363	500	34
	Moderately high waves of greater length; edges of crests break into spindrift. The foam is blown in well-marked streaks along the direction of the wind. Spray affects visibility	8	Fresh gale	34–40	37	15.6	24.9	31.6	6–20.5	13.9	9.9	376	530	37
					38	16.4	26.3	33.4	6.2–20.8	14.3	10.2	392	600	38
					40	18.2	29.1	37.0	6.5–21.7	15.1	10.7	444	710	42
8					42	20.1	32.1	40.8	7–23	15.8	11.3	492	830	47
	High waves. Dense streaks of foam along the direction of the wind. Sea begins to roll. Visibility affected.	9	Strong gale	41–47	44	22.0	35.2	44.7	7–24.2	16.6	11.8	534	960	52
					46	24.1	38.5	48.9	7–25	17.5	12.3	590	1110	57
	Very high waves with long overhanging crests. The resulting foam is in great patches and is blown in dense white streaks along the direction of the wind. On the whole, the surface of the sea takes on a white appearance. The rolling of the sea becomes heavy and shock-like. Visibility is affected.	10	Whole gale*	48–55	48	26.2	41.9	53.2	7.5–26	18.1	12.9	650	1250	63
					50	28.4	45.5	57.8	7.5–27	18.8	13.4	700	1420	69
					51.5	30.2	48.3	61.3	8–28.2	19.4	13.8	736	1560	73
					52	30.8	49.2	62.5	8–28.5	19.6	13.9	750	1610	75
9					54	33.2	53.1	67.4	8–29.5	20.4	14.5	810	1800	81
	Exceptionally high waves. Sea completely covered with long white patches of foam lying in direction of wind. Everywhere edges of wave crests are blown into froth. Visibility affected.	11	Storm*	56–63	56	35.7	57.1	72.5	8.5–31	21.1	15	910	2100	88
					59.5	40.3	64.4	81.8	10–32	22.4	15.9	985	2500	101
	Air filled with foam and spray. Sea white with driving spray. Visibility very seriously affected.	12	Hurricane*	64–71	>64	>46.6	74.5	94.6	10–35	24.1	17.2	—	—	—

* For hurricane winds (and often whole gale and storm winds) required durations and fetches are rarely attained. Seas are therefore not fully arisen.

† Revised December 1964 by L. Moskowitz and W. Pierson. Used courtesy of The Navy Oceanographic Office.

APPENDIX I

At Sea Data Analysis of Variance Summary Tables

Table I-1: Analysis of Variance of Motion Sickness Symptomatology Severity Scores

Source of Variation	df	MS	F	P<
Between Subjects	10			
A (Ship)	1	125.89	7.11	.05
Subjects W. Gr.	9	17.71		
Within Subjects	341			
B (Days)	1	40.63	15.54	.005
AxB	1	17.10	6.54	.05
BxSubj. W. Gr.	9	2.61		
C (Hours)	15	4.94	4.23	.001
AxC	15	2.15	1.85	.05
CxSubj. W. Gr.	135	1.17		
BxC	15	1.17	1.54	N.S.
AxBxC	15	1.15	1.52	N.S.
BxCxSubj. W. Gr.	135	0.76		
Total	351			

Table I-2: Analysis of Variance of Urine Output

Source of Variation	df	MS	F	P<
Between Subjects	10			
A (Ship)	1	188394.56	4.51	N.S.
Subjects W. Gr.	9	41804.89		
Within Subjects	77			
B (Days)		262630.88	6.44	.05
AxB		90158.19	2.21	N.S.
BxSubj. W. Gr.		40769.55		
C (Hours)	3	424380.00	17.66	.001
AxC	3	118618.19	4.94	.01
CxSubj. W. Gr.	27	24024.37		
BxC	3	4378.18	0.28	N.S.
AxBxC	3	249140.00	15.93	.001
BxCxSubj. W. Gr.	27	15643.26		
Total	87			

Table I-3: Analysis of Variance of Urine Specific Gravity

Source of Variation	df	MS	F	P<
Between Subjects	10			
A (Ship)	1	174.55	2.58	N.S.
Subjects W. Gr.	9	67.56		
Within Subjects	77			
B (Days)	1	785.45	10.27	.05
AxB	1	87.27	1.14	N.S.
BxSubj. W. Gr.	9	76.44		
C (Hours)	3	465.45	7.14	.005
AxC	3	203.64	3.12	.05
CxSubj. W. Gr.	27	65.19		
BxC	3	29.09	0.65	N.S.
AxBxC	3	494.54	11.13	.001
BxCxSubj. W. Gr.	27	44.44		
Total	87			

Table I-4: Analysis of Variance of Urinary Excretion Rates of 17-OHCS (Log Transform)

Source of Variation	df	MS	F	P<
Between Subjects	10			
A (Ship)	1	0.09	2.10	N.S.
Subjects W. Gr.	9	0.03		
Within Subjects	77			
B (Days)	1	0.02	0.39	N.S.
AxB	1	0.07	1.77	N.S.
BxSubj. W. Gr.	9	0.04		
C (Hours)	3	0.04	1.32	N.S.
AxC	3	0.02	0.76	N.S.
CxSubj. W. Gr.	27	0.03		
BxC	3	0.02	0.92	N.S.
AxBxC	3	0.04	1.82	N.S.
BxCxSubj. W. Gr.	27	0.02		
Total	87			

Table I-5: Analysis of Variance of Urinary Excretion Rates of Catecholamines (Log Transform)

Source of Variation	df	MS	F	P<
Between Subjects	10			
A (Ship)	1	0.30	0.92	N.S.
Subjects W. Gr.	9	0.33		
Within Subjects	77			
B (Days)	1	0.60	1.87	N.S.
AxB	1	0.04	0.11	N.S.
BxSubj. W. Gr.	9	0.32		
C (Hours)	3	0.28	1.45	N.S.
AxC	3	0.12	0.64	N.S.
CxSubj. W. Gr.	27	0.19		
BxC	3	0.32	2.16	N.S.
AxBxC	3	0.16	1.06	N.S.
BxCxSubj. W. Gr.	27	0.15		
Total	87			

Table I-6: Analysis of Variance of Heart Rate

Source of Variation	df	MS	F	P<
Between Subjects	10			
A (Ship)	1	10560.00	0.03	N.S.
Subjects W. Gr.	9	328928.00		
Within Subjects	341			
B (Days)	1	33861.82	7.88	.05
AxB	1	15185.45	3.53	N.S.
BxSubj. W. Gr.	9	4304.00		
C (Hours)	15	11339.63	21.11	.001
AxC	15	4142.54	7.71	.001
CxSubj. W. Gr.	135	537.24		
BxC	15	2583.27	4.83	.001
AxBxC	15	2385.46	4.46	.001
BxCxSubj. W. Gr.	135	535.11		
Total	351			

Table I-7: Analysis of Variance of Sweat Rate

Source	df	MS	F	P<
Between Subjects	10			
A (Ship)	1	4.58	1.10	N.S.
Subjects W. Gr.	9	4.19		
Within Subjects	341			
B (Days)	1	32.52	2.39	N.S.
AxB	1	18.84	1.39	N.S.
BxSubj. W. Gr.	9	13.60		
C (Hours)	15	6.06	0.74	N.S.
AxC	15	3.94	0.48	N.S.
CxSubj. W. Gr.	135	8.19		
BxC	15	11.57	1.17	N.S.
AxBxC	15	9.30	0.94	N.S.
BxCxSubj. W. Gr.	135	9.90		
Total	351			

Table I-8: Analysis of Variance of Aggression

Source	df	MS	F	P<
Between Subjects	10			
A (Ship)	1	26.27	4.84	N.S.
Subjects W. Gr.	9	5.43		
Within Subjects	341			
B (Days)	1	0.92	0.53	N.S.
AxB	1	1.11	0.64	N.S.
BxSubj. W. Gr.	9	1.74		
C (Hours)	15	0.12	1.25	N.S.
AxC	15	0.10	1.01	N.S.
CxSubj. W. Gr.	135	0.10		
BxC	15	0.16	2.52	.05
AxBxC	15	0.12	1.82	.01
BxCxSubj. W. Gr.	135	0.07		
Total	351			

Table I-9: Analysis of Variance of Anxiety

Source	df	MS	F	P<
Between Subjects	10			
A (Ship)	1	34.33	8.56	.05
Subjects	9	4.01		
Within Subjects	341			
B (Days)	1	0.04	0.33	N.S.
AxB	1	0.03	0.24	N.S.
BxSubj. W. Gr.	9	0.13		
C (Hours)	15	0.02	0.37	N.S.
AxC	15	0.08	1.30	N.S.
CxSubj. W. Gr.	135	0.06		
BxC	15	0.05	0.85	N.S.
AxBxC	15	0.07	1.20	N.S.
BxCxSubj. W. Gr.	135	0.05		
Total	351			

Table I-10: Analysis of Variance of Concentration

Source	df	MS	F	P<
Between Subjects	10			
A (Ship)	1	20.398	1.254	N.S.
Subjects W. Gr.	9	16.267		
Within Subjects	341			
B (Days)	1	0.002	0.004	N.S.
AxB	1	5.397	8.895	.05
BxSubj. W. Gr.	9	0.607		
C (Hours)	15	0.345	2.259	.01
AxC	15	0.170	1.631	N.S.
CxSubj. W. Gr.	135	0.104		
BxC	15	0.079	0.660	N.S.
AxBxC	15	0.113	0.941	N.S.
BxCxSubj. W. Gr.	135	0.120		
Total	351			

Table I-11: Analysis of Variance of Egotism

Source	df	MS	F	P<
Between Subjects	10			
A (Ship)	1	89.43	35.38	.001
Subjects	9	2.53		
Within Subjects	341			
B (Days)	1	0.01	0.04	N.S.
AxB	1	0.05	0.17	N.S.
BxSubj. W. Gr.	9	0.31		
C (Hours)	15	0.05	1.14	N.S.
AxC	15	0.04	0.92	N.S.
CxSubj. W. Gr.	135	0.04		
BxC	15	0.03	0.51	N.S.
AxBxC	15	0.04	0.70	N.S.
BxCxSubj. W. Gr.	135	0.06		
Total	351			

Table I-12: Analysis of Variance of Elation

Source	df	MS	F	P<
Between Subjects	10			
A (Ship)	1	41.63	17.81	.005
Subjects W. Gr.	9	2.34		
Within Subjects	341			
B (Days)	1	5.53	4.24	N.S.
AxB	1	1.81	1.39	N.S.
BxSubj. W. Gr.	9	1.30		
C (Hours)	15	1.16	12.48	.001
AxC	15	0.13	1.35	
CxSubj. W. Gr.	135	0.09		
BxC	15	0.43	4.20	.001
AxBxC	15	0.31	3.03	.005
BxCxSubj. W. Gr.	135	0.10		
Total	351			

Table I-13: Analysis of Variance of Fatigue

Source	df	MS	F	P<
Between Subjects	10			
A (Ship)	1	22.56	2.68	N.S.
Subjects W. Gr.	9	8.43		
Within Subjects	341			
B (Days)	1	2.81	6.23	.05
AxB	1	0.10	0.23	N.S.
BxSubj. W. Gr.	9	0.45		
C (Hours)	15	0.69	3.26	.001
AxC	15	0.26	1.24	N.S.
CxSubj. W. Gr.	135	0.21		
BxC	15	0.44	1.78	.05
AxBxC	135	0.25		.05
Total	351			

Table I-14: Analysis of Variance of Sadness

Source	df	MS	F	P<
Between Subjects	10			
A (Ship)	1	98.56	22.43	.005
Subjects W. Gr.	9	4.39		
Within Subjects	341			
B (Days)	1	0.47	0.18	N.S.
AxB	1	4.01	1.51	N.S.
BxSubj. W. Gr.	9	2.66		
C (Hours)	15	0.12	1.35	N.S.
AxC	15	0.12	1.37	N.S.
CxSubj. W. Gr.	135	0.09		
BxC	15	0.12	1.37	N.S.
AxBxC	15	0.10	1.23	N.S.
BxCxSubj. W. Gr.	135	0.84		
Total	351			

Table I-15: Analysis of Variance of Skepticism

Source	df	MS	F	P<
Between Subjects	10			
A (Ship)	1	35.97	4.57	N.S.
Subjects W. Gr.	9	7.88		
Within Subjects	341			
B (Days)	1	0.00	0.02	N.S.
AxB	1	0.46	2.71	N.S.
BxSubj. W. Gr.	9	0.17		
C (Hours)	15	0.07	1.08	N.S.
AxC	15	0.15	2.23	.01
CxSubj. W. Gr.	135	0.07		
BxC	15	0.11	1.69	N.S.
AxBxC	15	0.08	1.18	N.S.
BxCxSubj. W. Gr.	135	0.07		
Total	351			

Table I-16: Analysis of Variance of Social Affection

Source	df	MS	F	P<
Between Subjects	10			
A (Ship)	1	48.63	6.61	.05
Subjects W. Gr.	9	7.36		
Within Subjects	341			
B (Days)	1	0.41	0.14	N.S.
AxB	1	0.04	0.01	N.S.
BxSubj. W. Gr.	9	2.98		
C (Hours)	15	0.08	1.17	N.S.
AxC	15	0.05	0.71	N.S.
CxSubj. W. Gr.	135	0.07		
BxC	15	0.14	2.32	.01
AxBxC	15	0.06	0.98	
BxCxSubj. W. Gr.	135	0.05		
Total	351			

Table I-17: Analysis of Variance of Surgency

Source	df	MS	F	P<
Between Subjects	10			
A (Ship)	1	30.20	7.90	.05
Subjects W. Gr.	9	3.82		
Within Subjects	341			
B (Days)	1	13.30	6.75	.05
AxB	1	11.09	5.63	.05
BxSubj. W. Gr.	9	1.97		
C (Hours)	15	0.12	0.93	N.S.
AxC	15	0.20	1.55	N.S.
CxSubj. W. Gr.	135	0.13		
BxC	15	0.29	2.81	.005
AxBxC	15	0.22	2.31	.05
BxCxSubj. W. Gr.	135	0.10		
Total	351			

Table I-18: Analysis of Variance of Vigor

Source	df	MS	F	P<
Between Subjects	10			
A (Ship)	1	75.70	23.21	.001
Subjects W. Gr.	9	3.26		
Within Subjects	341			
B (Days)	1	1.39	0.98	N.S.
AxB	1	0.52	0.37	N.S.
BxSubj. W. Gr.	9	1.42		
C (Hours)	15	0.36	2.85	.005
AxC	15	0.10	0.76	N.S.
CxSubj. W. Gr.	135	0.13		
BxC	15	0.17	1.55	N.S.
AxBxC	15	0.13	1.23	N.S.
BxCxSubj. W. Gr.	135	0.11		
Total	351			

Table I-19: Analysis of Variance of Code Substitution

Source	df	MS	F	P<
Between Subjects	10			
A (Ship)	1	3545.80	2.11	N.S.
Subjects W. Gr.	9	1677.78		
Within Subjects	165			
B (Days)	1	618.41	23.39	.001
AxB	1	159.20	6.02	.05
BxSubj. W. Gr.	9	26.44		
C (Hours)	7	614.90	7.32	.001
AxC	7	301.90	3.59	.005
CxSubj. W. Gr.	63	84.01		
BxC	7	382.89	7.00	.001
AxBxC	7	100.57	1.84	N.S.
BxCxSubj. W. Gr.	63	54.67		
Total	175			

Table I-20: Analysis of Variance of Complex Counting (Log Transform)

Source of Variation	df	MS	F	P<
Between Subjects	10			
A (Ship)	1	891109.13	1.34	N.S.
Subjects W. Gr.	9	666538.63		
Within Subjects	165			
B (Days)	1	10941.82	0.22	N.S.
AxB	1	109914.50	2.22	N.S.
BxSubj. W. Gr.	9	49495.11		
C (Hours)	7	84613.25	3.60	.005
AxC	7	26641.55	1.13	N.S.
CxSubj. W. Gr.	63	23533.71		
AxBxC	7	39572.72	1.66	N.S.
BxCxSubj. W. Gr.	63	23868.44		
Total	175			

Table 1-21: Analysis of Variance of Critical Tracking Task (Square Transform)

Source of Variation	df	MS	F	P<
Between Subjects	10			
A (Ship)	1	183.77	0.32	N.S.
Subject W. Gr.	9	569.31		
Within Subjects	165			
B (Days)	1	118.55	4.97	N.S.
AxB	1	23.44	0.98	N.S.
BxSubj. W. Gr.	9	23.85		
C (Hours)	7	46.85	2.81	.05
AxC	7	29.93	1.79	N.S.
CxSubj. W. Gr.	63	16.67		N.S.
BxC	7	20.76	1.18	N.S.
AxBxC	7	28.40	1.61	N.S.
BxCxSubj. W. Gr.	63	17.58		
Total	175			

Table I-22: Analysis of Variance of Navigation Plotting (Total Completions)

Source	df	MS	F	P<
Between Subjects	10			
A (Ship)	1	2753.33	5.51	.05
Subjects W. Gr.	9	467.10		
Within Subjects	165			
B (Days)	1	83.57	9.01	.05
AxB	1	110.75	11.94	.05
BxSubj. W. Gr.	9	9.28		
C (Hours)	7	5.36	12.36	.001
AxC	7	12.97	4.49	.001
CxSubj. W. Gr.	63	2.89		
BxC	7	27.22	7.39	.001
AxBxC	7	8.76	2.38	.05
BxCxSubj. W. Gr.	63	3.69		
Total	175			

Table I-23: Analysis of Variance of Navigation Plotting (Total Correct)

Source of Variation	df	MS	F	P<
Between Subjects	10			
A (Ship)	1	659.66	3.02	N.S.
Subjects W. Gr.	9	219.12		
Within Subjects	165			
B (Days)	1	37.86	1.89	N.S.
AxB	1	111.07	5.56	.05
BxSubj. W. Gr.	9	19.99		
C (Hours)	7	81.98	7.02	.001
AxC	7	9.84	0.84	N.S.
CxSubj. W. Gr.	63	11.68		
BxC	7	37.39	4.20	.001
AxBxC	7	12.47	1.40	N.S.
BxCxSubj. W. Gr.	63	8.91		
Total	175			

Table I-24: Analysis of Variance of Spoke Test (Control)

Source of Variation	df	MS	F	P<
Between Ships	10			
A (Ship)	1	76.36	0.52	N.S.
Subjects W. Gr.	9	147.15		
Within Subjects	165			
B (Days)	1	97.78	6.21	.05
AxB	1	9.16	0.58	N.S.
BxSubj. W. Gr.	9	15.74		
C (Hours)	7	9.50	2.42	.05
AxC	7	7.91	2.02	N.S.
CxSubj. W. Gr.	63	3.93		
BxC	7	10.21	3.29	.005
AxBxC	7	3.05	0.98	N.S.
BxCxSubj. W. Gr.	63	3.10		
Total	175			

Table I-25: Analysis of Variance of Spoke Test (Experimental)

Source of Variation	df	MS	F	P<
Between Subjects	10			
A (Ship)	1	814.77	0.40	N.S.
Subjects W. Gr.	9	2022.22		
Within Subjects	165			
B (Days)	1	1071.45	12.18	.001
AxB	1	42.61	0.48	N.S.
BxSubj. W. Gr.	9	88.00		
C (Hours)	7	227.05	1.45	N.S.
AxC	7	144.25	0.92	N.S.
CxSubj. W. Gr.	63	156.27		
BxC	7	224.22	1.60	N.S.
AxBxC	7	171.82	1.23	N.S.
BxCxSubj. W. Gr.	63	140.08		
Total	175			

Table I-26: Analysis of Variance of Spoke Test (Difference)

Source of Variation	df	MS	F	P<
Between Subjects	10			
A (Ship)	1	392.29	0.18	N.S.
Subjects W. Gr.	9	2182.54		
Within Subjects	165			
B (Days)	1	521.93	9.00	.05
AxB	1	12.96	0.22	N.S.
BxSubj. W. Gr.	9	57.98		
C (Hours)	7	207.61	1.28	N.S.
AxC	7	101.67	0.63	N.S.
CxSubj. W. Gr.	63	162.04		
BxC	7	178.20	1.25	N.S.
AxBxC	7	167.92	1.18	N.S.
BxCxSubj. W. Gr.	63	142.27		
Total	175			

Table I-27: Analysis of Variance of Time Estimation (Log Transform)

Source of Variation	df	MS	F	P<
Between Subjects	10			
A (Ship)	1	0.046	0.672	N.S.
Subjects W. Gr.	9	0.069		
Within Subjects	165			
B (Days)	1	0.024	7.274	.05
AxB	1	0.002	0.767	N.S.
BxSubj. W. Gr.	9	0.003		
C (Hours)	7	0.005	1.900	N.S.
AxC	7	0.002	0.96	N.S.
CxSubj. W. Gr.	63	0.003		
BxC	7	0.003	1.24	N.S.
AxBxC	7	0.002	0.86	N.S.
BxCxSubj. W. Gr.	63	0.003		
Total	175			

TABLE I - 28

Summary of Physiological Measures ANOVA Results

Physiological Measure	Main Effects			Interactions			
	Ship	Day	Hour	S x D	S x H	D x H	S x D x H
Motion Sickness Symptomatology Severity (MSSS)	.05	.01	.001	.05	.05	-	-
Urine Output	-	.05	.001	-	.01	-	.001
Urine Spec. Gravity	-	.05	.01	-	.05	-	.001
17-OHCS	-	-	-	-	-	-	-
Catecholamines	-	-	-	-	-	-	-
Heart Rate	-	.05	.001	-	.001	.001	.001
Sweat Rate	-	-	-	-	-	-	-

Note. Numbers above represent alpha levels which were exceeded by specified F-ratios. Dash lines indicate nonsignificance.

TABLE I - 29

Summary of Mood Score ANOVA Results

Mood Dimension	Main Effects			Interactions			
	Ship	Day	Hour	S x D	S x H	D x H	S x D x H
Aggression	-	-	-	-	-	-	.05
Anxiety	.05	-	-	-	-	-	-
Concentration	-	-	.01	.05	-	-	-
Egotism	.001	-	-	-	-	-	-
Elation	.01	-	.001	-	-	.001	.01
Fatigue	-	.05	[illegible]	-	-	.05	.05
Sadness	.01	-	-	-	-	-	-
Skepticism	-	-	-	-	.05	-	-
Social Affection	.05	-	-	-	-	.01	-
Surgency	.05	.05	-	.05	-	.01	.01
Vigor	.001	-	.01	-	-	-	-

Note: Numbers aboe represent alpha levels which were exceeded by spedified F-ratios. Dash lines indicate nonsignificance.

TABLE I - 30

Summary of Performance Test Scores ANOVA Results

Performance Task	Main Effects			Interactions			
	Ship	Day	Hour	S x D	S x H	D x H	S x D x H
Code Substitution	-	.001	.001	.05	.01	.001	-
Complex Counting	-	-	.01	-	-	-	-
Critical Tracking Task	-	-	.05	-	-	-	-
Nav/Plot Completions	.05	.05	.001	.05	.001	.001	.05
Nav/Plot Number Correct	-	-	.001	.05	-	.001	-
Spoke Test Times							
Control	-	.05	.05	-	-	.01	-
Experimental	-	.001	-	-	-	-	-
Difference	-	.05	-	-	-	-	-
Time Estimation (12 sec)	-	.05	-	-	-	-	-

Note: Numbers above represent alpha levels which were exceeded by specified F-ratios. Dash lines indicate nonsignificance.

APPENDIX J

Tables of Correlations Between Experimental Variables

TABLE J - 1

Correlations Between Individual Daily Means of Physiological Measures Taken at Sea

Measure	1	2	3	4	5	6	7
1. Motion Sickness (MSSS)	1						
2. Urine Output	-.67	1					
3. Urine Sp. Gr.	.39	-.82			(n = 22)		
4. 17-OHCS	-.26	.40	-.47	1			
5. Catecholamines	.17	.10	-.18	-.02	1		
6. Heart Rate	-.04	.15	-.09	.19	-.11	1	
7. Sweat Rate	.19	-.20	-.04	.21	-.04	-.07	1

$r > .40$, $p < .05$
$r > .52$, $p < .05$

TABLE J - 2

Correlations Between Individual Daily Means of Affective State Measures Taken at Sea

(n = 22)

Measure	1	2	3	4	5	6	7	8	9	10	11
1. Agression	1										
2. Anxiety	.67	1									
3. Concentration	.33	.32	1								
4. Egotism	.48	.56	.60	1							
5. Elation	.15	.33	.36	.51	1						
6. Fatigue	.74	.72	.42	.32	.40	1					
7. Sadness	.37	.44	.27	.69	.68	.40	1				
8. Skepticism	.74	.43	.12	.74	.12	.50	.44	1			
9. Social Affection	.40	.33	.28	.39	.70	.80	.38	.35	1		
10. Surgency	-.50	.18	.60	.50	.77	-.28	.50	.10	.66	1	
11. Vigor	.37	.57	.55	.57	.86	.27	.68	.30	.60	.66	1

$r > .40$, $p < .05$
$r > .52$. $p < .01$

TABLE J - 3

Correlations Between Individual Daily Means of Physiological and Affective State Measures Taken at Sea

Measure	Motion Sickness	Urine Output	Urine Sp. Gr.	17-OHCS	Catecholamines	Heart Rate	Sweat
Aggression	.56	-.28	.11	-.10	-.19	.53	-.02
Anxiety	.68	-.25	.07	-.28	.29	.35	.11
Concentration	.27	.05	-.19	.18	.34	.24	.19
Egotism	.51	-.40	.11	-.40	.20	-.13	.14
Elation	.17	.02	-.21	.00	.20	-.03	.01
Fatigue	.53	-.30	.12	.01	.03	.65	.14
Sadness	.51	-.32	-.07	.02	.18	-.01	.19
Skepticism	.38	-.30	.14	-.21	-.04	.24	-.07
Social Affection	.26	-.16	.02	-.22	.02	-.09	.15
Surgency	.22	-.16	.02	-.15	.13	-.37	.00
Vigor	.47	-.13	-.07	.01	.32	-.02	.07

$r > .40$, $p < .05$
$r > .52$, $p < .01$

$n = 22$

TABLE J - 4

Correlations Between Individual Daily Means of
Affective State and Test Compartment Measures Taken at Sea

	Aggression	Anxiety	Concentration	Egotism	Elation	Fatigue	Sadness	Skepticism	Social Affect.	Surgency	Vigor
Vert. rms g	.53	.68	.34	.88	.72	.45	.76	.57	.59	.53	.80
Lat. rms g	.53	.69	.33	.88	.70	.47	.77	.58	.58	.52	.79
Long. rms g	-.40	-.61	-.37	-.78	-.[illegible]1	-.46	-.61	-.48	-.52	.26	-.65
Vert. Hz	-.44	-.65	-.37	-.82	-.56	-.48	-.66	-.52	-.54	-.32	-.70
Lat. Hz	-.55	-.63	-.26	-.81	-.77	-.35	-.78	-.54	-.55	-.67	-.78
Long. Hz	-.5[illegible]	-.68	-.33	-.87	-.65	-.48	-.74	-.56	-.57	-.45	-.76
Vert. Max. Amp	.50	.67	.30	.85	.64	.48	.74	.57	.54	.47	.75
Lat. Max. Amp	.52	.69	.34	.88	.69	.47	.76	.57	.58	.50	.78
Long. Max. Amp	-.46	-.66	-.36	-.84	-.59	-.48	-.68	-.54	-.55	-.35	-.72
Vert. Max. Amp. Hz	.54	.69	.33	.88	.73	.46	.78	.58	.58	.56	.80
Lat. Max. Amp. Hz	.53	.69	.34	.88	.70	.47	.76	.57	.58	.51	.79
Long. Max. Amp. Hz	.51	.66	.28	.84	.65	.46	.75	.56	.54	.50	.75
Temperature	-.47	-.52	-.27	-.67	-.71	-.25	-.62	-.44	-.49	-.61	-.67
Rel. Humidity	.12	.31	.16	.37	.04	.34	.25	.23	.20	.14	.22

r > .40, p < .05
r > .52, p < .01

n = 22

TABLE J - 5

Correlations Between Individual Daily Means of Performance Task Measures Taken at Sea

Measure	1	2	3	4	5	6	7	8	9
1. Code Substituion (# attempted)	1								
2. Complex Counting (% correct)	.27	1							
3. Critical Tracking (bandwidth limit)	.21	.40	1			(n = 22)			
4. Nav/Plot (attempts)	.80	.62	.31	1					
5. Nav/Plot (# correct)	.78	.63	.30	.85	1				
6. Spoke Test (control) (completion time)	-.11	-.36	-.20	-.40	-.43	1			
7. Spoke Test (expmtl.) (completion time)	-.62	-.29	-.69	-.52	-.60	.12	1		
8. Spoke Test (differ.) (time interval)	-.58	-.19	-.68	-.40	-.48	-.16	.96	1	
9. Time Estimation (12 sec. estimate)	-.39	.18	.40	-.23	-.30	.30	.18	.17	1

$r > .40$, $p < .05$
$r > .52$, $p < .01$

TABLE J - 6

Correlations Between Individual Daily Means of Performance Task and Affective State Measures Taken at Sea

Measure	1	2	3	4	5	6	7	8	9
1. Code Substitutions (#)	1								
2. Complex Count. (% correct)	.27	1							
3. CTT (λc)	.21	.40	1						
4. Nav/Plot (attempts)	.80	.62	.31	1					
5. Nav/Plot (# correct)	.78	.63	.30	.85	1				
6. Spoke Control (time)	-.11	-.36	-.02	-.41	-.43	1			
7. Spoke Exptl. (time)	-.62	-.29	-.69	-.52	-.60	.12	1		
8. Spoke Diff. (time)	-.58	-.19	-.68	-.40	-.48	-.16	.96	1	
9. Time Est. (12 sec.)	-.39	.18	.40	-.23	-.30	.03	.18	.17	1
10. Aggression	-.20	-.13	-.12	-.35	-.05	.03	-.05	-.06	.05
11. Anxiety	-.26	-.42	-.28	-.51	-.35	.01	.05	.05	-.18
12. Concentration	-.20	.11	.63	-.13	-.07	.19	-.31	-.36	.37
13. Egotism	-.24	-.29	-.39	-.10	-.17	.29	.27	.19	.02
14. Elation	-.24	-.22	.18	-.33	-.35	.16	.07	.02	.43
15. Fatigue	-.53	-.18	-.28	-.50	-.26	.06	.31	.29	.10
16. Sadness	-.62	-.17	-.11	-.65	-.49	.27	.37	.30	.34
17. Skepticism	-.11	-.06	-.29	-.31	-.01	.10	.10	.07	-.04
18. Soc. Affect.	-.16	.04	.23	-.34	.18	.14	.05	.06	.01
19. Surgency	-.05	-.07	.10	-.09	-.18	.10	.01	-.02	.10
20. Vigor	-.24	-.12	.26	-.31	-.20	-.03	-.11	-.11	.37

$r > .40$, $p < .05$
$r > .52$, $p < .01$

$n = 22$

TABLE J - 7

Correlations Between Individual Daily Means of Performance Task, Physiological and Test Compartment Motion Measures Taken at Sea

Measure	Urine Output	Urine Sp. Grav.	17-OHCS	Catecholamines	Heart Rate	Sweat Rate	MSSS Score
Code Substitutions	.04	-.20	-.53	.48	-.64	-.18	-.64
Complex Counting	.61	-.43	.19	-.47	.09	.08	-.56
Critica ~~racking	-.43	-.33	-.43	.85	.14	.03	-.69
Time Est... ion	-.72	.52	-.37	.79	-.12	-.27	.15
Nav/Plot Attempts	.68	-.37	.29	-.78	-.17	.18	-.63
Nav/Plot # Correct	.33	43	.27	-.81	-.20	.15	-.54
Spoke Control	.06	.83	.36	-.60	.43	.21	.72
Spoke Experimental	.60	-.53	.45	-.72	.29	.16	.52
Spoke Difference	.30	.52	.52	-.82	-.08	-.06	-.13
Vertical Hz	.62	.08	.59	-.78	.07	.13	-.24
Lateral Hz	.28	.07	.38	-.56	.07	.13	-.22
Longitudinal Hz	.40	-.18	.48	-.47	.03	.13	-.22
Vertical rms g	-.26	-.89	.05	-.19	.22	.07	.50
Lateral rms g	-.67	.82	-.56	.89	.19	-.05	.59
Longitudinal rms g	-.46	-.33	-.05	.20	.42	.24	.43
Vert. Max. Amp. Hz	-.66	.25	-.58	.80	-.09	-.08	-.11
Lat. Max. Amp. Hz	-.11	.21	-.25	.03	.12	.14	-.05
Long. Max. Amp. Hz	-.30	.20	-.42	.23	-.22	-.24	-.06
Vert. Max. Amp.	-.60	-.15	-.58	.88	.18	-.01	.51
Lat. Max. Amp.	-.11	-.19	-.25	-.29	.18	.06	.44
Long. Max. Amp.	-.55	.14	-.47	.73	.42	.10	.43

$r > .40, p < .05$　　n = 22

$r > .52, p < 01$

TABLE J - 8

Correlations Between Individual Daily Means of Performance Task and Test Compartment Motion Measures Taken at Sea

	Code Substitution (# completed)	Complex Counting (% correct)	Critical Tracking (bandwidth)	Navigation/Plotting (# completed)	Navigation/Plotting (# correct)	Spoke (Control) (time)	Spoke (Experimental) (time)	Spoke (Difference) (time)	Time Estimation (12 second est.)
Vert. rms g	-.41	-.33	-.17	-.59	-.46	.20	.18	.13	.23
Lat. rms g	-.43	-.33	-.19	-.61	-.49	.23	.21	.15	.25
Long. rms g	.38	.23	.17	.51	.36	-.21	-.21	-.15	-.24
Vert. Hz	.41	.26	.18	.56	.41	-.24	-.23	-.16	-.26
Lat. Hz	.36	.35	.14	.56	.46	-.15	-.13	-.09	-.19
Long. Hz	.44	.32	.20	.61	.48	-.26	-.24	-.16	-.27
Vert. Max. Amp.	-.45	-.33	-.22	-.62	-.51	.27	.25	.17	.27
Lat. Max. Amp.	-.43	-.33	-.19	-.61	-.48	.23	.21	.15	.26
Long. Max. Amp.	.42	.28	.19	.57	.43	-.24	-.22	-.16	-.26
Vert. Max. Amp. Hz	-.42	-.34	-.18	-.61	-.48	.21	.20	.13	.24
Lat. Max. Amp. Hz	-.42	-.33	-.18	-.60	-.47	.22	.20	.14	.25
Long. Max. Amp. Hz	-.45	-.34	-.21	-.62	-.52	.27	.24	.17	.26
Temperature	.23	.27	.04	.39	.29	-.01	-.01	-.01	-.10
Relative Humidity	-.32	-.10	-.20	-.33	-.27	.30	.28	.20	.24

$r > .40$, $p < .05$
$r > .52$, $p < .01$

$n = 22$